U.S. DEPARTMENT OF COMMERCE
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PB-245 848

INSPECTION MANUAL FOR ENFORCEMENT OF NEW SOURCE PERFORMANCE STANDARDS: MUNICIPAL INCINERATORS

PEDCo-Environmental Specialists, Incorporated

PREPARED FOR
Environmental Protection Agency

February 1975

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EPA 340/1-75-003
FEBRUARY 1975

Stationary Source Enforcement Series

INSPECTION MANUAL FOR ENFORCEMENT OF NEW SOURCE PERFORMANCE STANDARDS

MUNICIPAL INCINERATORS

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement
Office of General Enforcement
Washington, D.C. 20460

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TECHNICAL REPORT DATA
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1. REPORT NO. EPA 340/1-75-003	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Inspection Manual for the Enforcement of New Source Performance Standards: Municipal Incinerators		5. REPORT DATE Issue: February 1975 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) K. Axetell, T. W. Devitt, N. J. Kulujian		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS PEDCo-Environmental Specialists, Inc. Suite 13, Atkinson Square Cincinnati, Ohio 45246		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO. 68-02-1073
12. SPONSORING AGENCY NAME AND ADDRESS Environmental Protection Agency Office of Air and Water Programs Research Triangle Park, North Carolina 27711		13. TYPE OF REPORT AND PERIOD COVERED Final 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

One of a series of NSPS Enforcement Inspection Manuals

16. ABSTRACT

This document presents guidelines to enable enforcement personnel to determine whether new or modified municipal incinerators comply with New Source Performance Standards (NSPS). Key parameters identified during subsequent inspections to determine the facility's compliance status. The incineration process, atmospheric emissions from these processes, and emission control methods are described. The inspection methods and types of records to be kept are discussed in detail.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Incinerators, refuse disposal Air pollution control Verification inspection Performance tests	New Source Performance Standards Enforcement Emission testing	13 B 14 D

PRICES SUBJECT TO CHANGE

18. DISTRIBUTION STATEMENT Release unlimited	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 91
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE 4.75 - 2.25

EPA Form 2220-1 (9-73)

U.S. GOVERNMENT PRINTING OFFICE: 1975— 210-810:39

INSPECTION MANUAL FOR THE ENFORCEMENT OF NEW SOURCE PERFORMANCE STANDARDS

MUNICIPAL INCINERATORS

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Contract No. 68-02-1073

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Prepared for

U. S. ENVIRONMENTAL PROTECTION AGENCY
Division of Stationary Source Enforcement
Washington, D. C.

January 1975

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The Enforcement Technical Guideline series of reports is issued by the Office of Enforcement, Environmental Protection Agency, to assist the Regional Offices in activities related to enforcement of implementation plans, new source emission standards, and hazardous emission standards to be developed under the Clean Air Act. Copies of Enforcement Technical Guideline reports are available - as supplies permit - from Air Pollution Technical Information Center, Environmental Protection Agency, Research Triangle Park, North Carolina 27711, or may be obtained, for a nominal cost, from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

ACKNOWLEDGMENT

This report was prepared under the direction of Mr. Timothy W. Devitt. Principal authors were Messrs. Norman J. Kulujian and Kenneth Axetell.

Project Officer for the U.S. Environmental Protection Agency was Mr. John Butler. The authors appreciate the contributions made to this study by Mr. Butler and other members of the Division of Stationary Source Enforcement.

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1.0 INTRODUCTION

Pursuant to Section 111 of the Clean Air Act, the Administrator of the U.S. Environmental Protection Agency (EPA) has promulgated particulate emission standards of performance for new and modified municipal incinerators. As specified in 40 CFR Part 60, these standards apply to all incinerators which burn solid waste, more than 50% of which is classified as municipal refuse, and have a charging rate of over 50 tons per day. These standards were promulgated on December 23, 1971 and apply to all sources whose construction or modification commenced after August 17, 1971.

Each State may develop a program for enforcing new source performance standards (NSPS) applicable to sources within its boundaries. If this program is adequate, EPA will delegate implementation and enforcement authority to the state for all affected sources with the exception of those owned by the U.S. Government. Coordination of activities between the state agency and EPA, both Regional Office and Division of Stationary Source Enforcement, is thus essential for effective operation of the NSPS program. To facilitate such state participation EPA has established guidelines identifying the administrative procedures States should adopt to effectively implement and enforce the NSPS program.

The long-term success of the NSPS program depends largely upon the adoption of an effective plant inspection program. Primary functions of the inspection program are monitoring the NSPS performance tests and routine field surveillance. This manual provides guidelines for conducting such field inspections. However, the same basic inspection procedures presented in this manual should also be of use in enforcing emission regulations contained in state air quality implementation plans. A summary of state emission regulations, presented in Section 2.1, is available for comparison to NSPS for municipal incinerators.

2.0 SIP REQUIREMENTS AND NSPS

Standards of air pollution control performance for new and modified incinerators were originally proposed on August 17, 1971. The standards promulgated on December 23, 1971, altered the particulate sampling method, but the emission limits were adjusted to provide the same degree of particulate control as the originally proposed standards. New source performance standards are subject to Federal regulation code 40 CFR 60. The title 40 designates "Protection of Environment;" the part 60 classifies new sources.

An amendment on May 2, 1973, recognized that start-ups, shutdowns, and malfunctions are not representative conditions of performance tests unless otherwise specified. In addition, the amendment simplified reporting requirements. On June 14, 1974, sampling time requirements for particulate matter and gaseous pollutants were reduced, because performance test results did not show any decrease in the accuracy or precision using shorter sampling times.

On November 12, 1974, significant changes were proposed for new and modified sources. The most important amendments were revisions in opacity provisions. Incinerators are unaffected, since mass/concentration standards only apply.

2.1 EXISTING SOURCES; STATE IMPLEMENTATION PLANS

Particulate emission standards promulgated by the states for municipal incinerators range from a low of 0.02 lb/100 lbs refuse in North Carolina for incinerators with capacities over 2000 lb/hr to a high of 0.50 lb/100 lbs refuse in New York for incinerators not in New York City, Nassau or Westchester Counties. The emission standards of most states for larger facilities range from 0.08 lb/100 lbs refuse to 0.20 lb/100 lbs refuse. Emission regulations for smaller plants are generally between 0.19 lb/100 lbs refuse and 0.30 lb/100 lbs refuse. Table 2.1 is a tabulation by state of the regulations limiting particulate emissions from municipal incinerators. The values are illustrative only and should not be used for enforcement purposes since in many cases the states' regulations contain a variety of qualifications and exceptions.

Table 2.1 REPRESENTATIVE PARTICULATE EMISSION STANDARDS FOR MUNICIPAL INCINERATORS

(lb/1000 lbs of refuse)

STATE	CAPACITY, lbs/hr			
	0-199	200-1999	2000-9999	>10000
Alabama	0.20	0.20	0.20	0.20
Alaska	0.29	0.19-0.93	0.093	0.093
Arizona	0.09-0.22	0.09-0.22	0.09-0.22	0.09-0.22
Arkansas	0.29	0.19	0.19	0.19
California	Each county has its own regulation			
Colorado	0.15	0.09	0.09	0.09
Connecticut	0.08/0.23	0.08/0.23	0.08/0.23	0.08/0.23
Delaware	0.20	0.20	.19-None	None
Dist of Columbia	0.03/0.08	0.3/0.08	0.3/0.08	0.3/0.08
Florida	None	None	None-0.08	0.08
Georgia	0.10/0.19	0.10/0.19	0.10-0.08/0.19	0.08/0.19
Hawaii	0.20	0.20	0.20	0.20
Idaho	0.20	0.20	0.20	0.20
Illinois	0.09/0.19	0.09/0.19	0.081/0.19	0.081-0.5/0.19
Indiana	0.39	0.39-0.23	0.23	0.23
Iowa	0.20	0.20	0.20	0.20
Kansas	0.29	0.19	0.19	0.19-0.09
Kentucky	0.19	0.19	0.19-0.08/0.19	0.08/0.19
Louisiana	0.19	0.19	0.19	0.19
Maine	0.19	0.19	0.19-0.08	0.08
Maryland	0.03-0.25	0.03-0.19	0.09-0.03	0.03
Massachusetts	0.05/0.09	0.05/0.09	0.05/0.09	0.05/0.09
Michigan	0.03	0.03	0.03	0.03
Minnesota	0.03	0.20	0.10	0.10
Mississippi	0.09/0.19	0.09/0.19	0.09/0.19	0.09/0.19
Missouri	0.19-0.29	0.19	0.19	0.19
Montana	0.29	0.19	0.19	0.19
Nebraska	0.19	0.19	0.09	0.09
Nevada	Opacity	Opacity	Opacity	Opacity
New Hampshire	0.29	0.19	0.19	0.19
New Jersey	0.19	0.19	0.09	0.09
New Mexico	Prohibited/0.09	Prohibited/0.09	Prohibited/0.09	Prohibited/0.09
New York	0.2-0.3/0.2-0.5	0.2-0.22/0.2-0.5	0.15-0.22/0.15-0.5	0.08-0.22/0.08-0.5
North Carolina	0.20	0.20	0.02	0.02
North Dakota	Based on Formula			
Ohio	0.20-0.10	0.10	0.10	0.10
Oklahoma	0.40	0.40	0.40	0.40
Oregon	0.09/0.29	0.09/0.19	0.09/0.19	0.09/0.19
Pennsylvania	0.09	0.09	0.09	0.09
Rhode Island	0.15	0.15	0.08	0.08
South Carolina	0.5 lbs/10^6 BTU Input			
South Dakota	0.20	0.20	0.20	0.20
Tennessee	0.20/0.6	0.20/0.4	0.10/0.4	0.10/0.4
Texas	None	None	None	None
Utah	85% Control			
Vermont	0.10	0.10	0.10	0.10
Virginia	0.13	0.13	0.13	0.13
Washington	0.09/0.09-0.19	0.09/0.09-0.19	0.09/0.09-0.19	0.09/0.09-0.19
West Virginia	0.41	0.27	0.27	0.27-0.13
Wisconsin	0.17/0.34	0.11/0.34-0.27	0.11-0.08/0.27	0.08/0.27
Wyoming	0.20	0.20	0.20	0.20

Where a range is given limit depends on location, date, capacity.
Where new and existing regulations differ - new source limit/existing source limit.

Forty-two states limit visible emissions from new incinerators to below 20 percent opacity. Regulations range from "no visible discharge" in Maryland and the District of Columbia to 60 percent opacity for short periods in Pennsylvania and Vermont. Table 2.2 is a tabulation of opacity limitations for the various states; the same limitations apply to this listing as apply to Table 2.1.

2.2 SUMMARY OF NSPS

The NSPS apply to all incinerators with charging rates of more than 50 tons of municipal refuse per 24 hours, the construction or modification of which was commenced after August 17, 1971. Important provisions are summarized below; a complete copy of the regulations, plus revisions through November 1974, is presented in Appendix A.

2.2.1 Emission Standard

Particulate matter is the only pollutant discharge from incinerators limited by an emission standard. The maximum average permissible emission rate is 0.18 g/NM^3 (0.08 gr/dscf) corrected to 12 percent CO_2, over a period of 2 hours or less.

2.2.2 Performance Testing

The regulations require that the owner or operator of a new source subject to the performance standards conduct a test at representative performance within 60 days after achieving full operation, but not more than 180 days after initial start-up, and furnish a written report of the results of the test to EPA, Office of General Enforcement.

Requirements for new source performance tests are summarized in Table 2.3. Any alternative or equivalent test procedures must be approved by the EPA Administrator. Additional tests by EPA personnel may be performed at any reasonable time.

2.2.3 Monitoring Requirements

Incinerator owners or operators are subject to monitoring the following items.

- Daily burning rates in tons of as-charged refuse per day.
- Daily hours of operation.
- Occurrences and durations of any start-ups, shutdowns, or malfunctions.

Table 2.2 REPRESENTATIVE EQUIVALENT OPACITY STANDARDS FOR MUNICIPAL INCINERATORS

STATE	% OPACITY[a]
Alabama	20
Alaska	20-40
Arizona	40
Arkansas	20-40
California	Diff. for each county
Colorado	20
Connecticut	20
Delaware	20
Dist. of Columbia	No visible discharges
Florida	20
Georgia	20-40
Hawaii	20-40
Idaho	20-40
Illinois	30
Indiana	40
Iowa	20
Kansas	20
Kentucky	20
Louisiana	20
Maine	20
Maryland	No visible discharges
Massachusetts	20
Michigan	40
Minnesota	20
Mississippi	20
Missouri	20
Montana	20
Nebraska	20
Nevada	20
New Hampshire	--
New Jersey	20
New Mexico	20
New York	20-40
North Carolina	--
North Dakota	20
Ohio	20
Oklahoma	20
Oregon	20-40
Pennsylvania	20-60
Rhode Island	20
South Carolina	20-40
South Dakota	20
Tennessee	20-40
Texas	20-30
Utah	20
Vermont	40-60
Virginia	20
Washington	20-40
West Virginia	20
Wisconsin	20
Wyoming	20

[a] Does not include opacity of uncombined water.
Where range is given limit depends on location, date, whether new or existing source etc.

Table 2.3 NEW SOURCE PERFORMANCE TEST REQUIREMENTS FOR INCINERATORS

Provision/regulation	Test requirements
1. Incinerator operation 60.8 (c)	- Refuse charging rate at representative performance (rather than rated capacity) - Refuse representative of normal operation
2. Sampling method 60.54 (a, c)	- Particulate emissions sampled by EPA procedure (Method 5 in 60 CFR 40) using EPA sampling train. Compliance based only on material collected in probe and dry filter - Simultaneously with each particulate run, an integrated gas sample is required to determine the CO_2 content in the gas stream
3. Sampling period 60.54 (b) 60.8 (e)	- Each sampling period minimum of 1 hour and 30 scf sampling volume (dry basis) - Emissions are determined as average of three repetitive samplings
4. Timetable 60.8 (a, d)	- Testing within 60 days after achieving full operation, but not more than 180 days after start-up - Owner or operator must notify EPA of test date at least 30 days prior to testing
5. Required provision of facilities by owner or operator 60.8 (d)	- Sampling ports - Safe sampling platform - Safe access to platform - Utilities for sampling and testing equipment

- Particulate emission measurements.

2.2.4 Recordkeeping and Reporting

Daily charging rates and hours of operation must be recorded and summarized by the owner or operator. These records and summaries, plus data from any particulate emission measurements, must be retained for a period of at least two years and must be made available to EPA upon request. Records of any emissions resulting from malfunctions or start-ups measured or estimated to be greater than those allowed by NSPS must be submitted to the Administrator on the 15th day following the end of each calendar quarter.

To comply with the new source performance standards, the owner or operator is required to furnish written notification to the EPA Office of General Enforcement on three occasions:

- Notice of the anticipated date of initial start-up of the facility, not more than 60 days or less than 30 days prior to that date;
- Notice of the date of actual initial start-up, within 15 days after such date; and
- Notice of the date for conduct of the performance test, at least 30 days prior to that date.

As mentioned earlier, the owner or operator must also submit a written report of performance test results to the EPA Office of General Enforcement.

3.0 PROCESS DESCRIPTION, ATMOSPHERIC EMISSIONS AND EMISSION CONTROL METHODS

A brief description of the incineration process is presented below to familiarize the inspector with the basic theory. Many references dealing with incinerator theory and design are available.[1,2,3,4] Particulate emissions and control techniques are discussed in detail.

3.1 PROCESS DESCRIPTION

Municipal incineration is a controlled combustion process for reducing municipal refuse to gases and a residue containing little or no combustible material. Although most municipal incinerators are designed solely to reduce the volume of refuse for ultimate disposal, heat generated by the incineration process can also be efficiently utilized for production of electric power or steam.

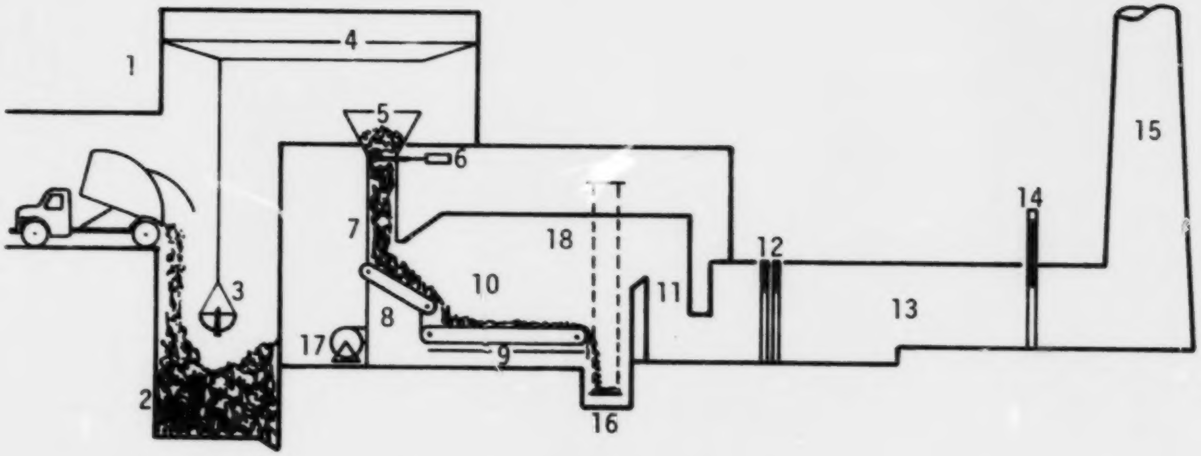
During combustion, the moisture in the refuse is first evaporated, and then the combustible portion is vaporized and oxidized. The major end products of incineration are carbon dioxide, water vapor, and non-combustible ash.

The component subsystems of a municipal incinerator are:

- refuse holding and charging
- combustion chambers
- air supply
- residue handling
- air pollution control equipment

These components are shown schematically in Figure 3.1 and briefly discussed in this section.[4]

There are numerous municipal incinerator designs in use, employing different grate types or combustion chamber configurations. Common mechanical grate types are traveling, reciprocating, and rocking; furnace types include rectangular and rotary kiln, with either refractory or waterwall interiors. The inspector will rarely encounter the older type of batch incinerators with stationary grates, which are now seldom used or new configurations such as



1. INCINERATOR
2. STORAGE PIT
3. GRAP BUCKET
4. BRIDGE CRANE
5. CHARGING HOPPER
6. HOPPER GATE
7. WATER-COOLED HOPPER
8. FEEDING AND DRYING STOKER
9. BURNING STOKER
10. PRIMARY COMBUSTION CHAMBER
11. SECONDARY COMBUSTION CHAMBER
12. GAS-CLEANING CHAMBER
13. FLUE
14. DAMPER
15. STACK
16. ASH CONVEYOR
17. FORCED-DRAFT FAN
18. REFACTORY ENCLOSURES

Figure 3.1 Schematic of typical municipal incinerator.[4]

fluidized-bed incinerators and pyrolysis units, which are still in the developmental stage. The incinerator subsystems and inspection procedures described in this manual generally apply to the rectangular furnace with mechanical grates.

Refuse is delivered in trucks to the storage pit at the incinerator. Before dumping, the trucks usually pass over a scale, so that the total daily weight of refuse entering the facility can be measured and recorded.

An elevated crane with a clam-shell bucket or grapple lifts the refuse from the storage pit into a charging hopper and gravity chute, which continuously feeds the incinerator. The chute is kept filled at all times to provide an air seal and prevent escape of smoke and heat from the incinerator into the charging area.

The furnace grates transport the solid waste through the furnace and promotes combustion by agitation, allowing passage of underfire air up through the grates and the bed of waste. Agitation is achieved either by gently turning the burning refuse as it is moved to successive grate sections or by tumbling from one grate or tier to another in the furnace. Although the tumbling action contributes to entrainment of particulate matter in the gas stream, the amount of entrainment is more a function of the flow rate of underfire air.

The loading or burning rate for grates is commonly expressed as pounds of refuse per square foot-hour (lb/ft^2-hr). Rates up to 60 lb/ft^2-hr are acceptable; higher burning rates lead to incomplete refuse burnout and therefore to excessive emissions.

Most municipal incinerators of capacities greater than 50 ton/day are composed of a series of chambers, although this separation often is not clearly visible from the outside of the furnaces. The chambers are designated as ignition, mixing, and (secondary) combustion.

Drying, ignition, and burning of the waste occurs in the ignition chamber. The grates are located in this section and residue is removed at its far end. A minimum of 0.5 second retention time should be provided for gases in the mixing chamber.

Combustion of the incinerator gases and suspended particulate matter is completed in the secondary combustion or expansion chamber. A minimum retention time of 1.0 second and maximum velocity of 10 ft/sec are recommended for the secondary combustion chamber.

Temperatures in the furnace must reach at least 1500°F to provide for burnout of smoke and oxidation of most odorous compounds. Maximum furnace temperatures (actual flame temperature) reach 2100 to 2500°F, but temperatures at most locations in the ignition chamber are in the range of 1800 to 2000°F. Gases exiting the combustion chamber are usually between 1400 and 1800°F; temperatures in this region of the furnace below 1200°F are undesirable. The exhaust gases are cooled to 350 to 700°F following their conditioning with cooling air, water spray, or heat exchange.

Underfire, overfire, and secondary air are supplied by forced-draft centrifugal fans. The underfire and overfire air enters through a series of adjustable ports located below and above the grates, respectively. Secondary air for turbulence and temperature control is added through high-velocity jets in the side walls and roof of the furnace. Additional air to move the combustion gases through the furnace, gas cleaning equipment, breeching, and out the stack is provided by induced-draft fans located between the secondary combustion chamber (or air pollution control equipment) and the stack.

Two important measures of the air supply are the percent underfire air and the percent excess air. The underfire air basically controls the rate of burning, whereas excess air ensures complete combustion and reduces furnace temperatures. With proper operation the underfire air rate should not exceed 100 scfm/ft^2 of grate area. An underfire to overfire air ratio of 1:2 is recommended for regular refuse and a ratio of 1:1 is considered more appropriate for wet refuse.

Residue is discharged from the end of the burning grate into ash hoppers. The hoppers are usually quench tanks which reduce the fire hazards of handling the residue and control dust entrainment from the ash. A drag or apron pan conveyor continuously removes the wet residue from the bottom of the incinerator.

The remainder of the residue is in the form of siftings and fly ash. The siftings are either removed from beneath the grates manually through clean-out doors, or are collected in troughs and mechanically conveyed to the residue hopper. Fly ash captured in gas-cleaning devices may be handled separately or combined with the other residue.

Most incinerators are designed to allow dump trucks to load the residue directly from the drag-out conveyor for delivery to a landfill or other disposal site.

3.2 ATMOSPHERIC EMISSIONS

The major emission point from a municipal incinerator, and the only one subject to the NSPS, is the furnace stack. The only pollutant discharge subject to the NSPS is particulate matter. New incinerators operate with an uncontrolled emission rate of about 35 lb per ton of refuse. Based on 50 percent air, this rate is equivalent to approximately 3.6 g/NM^3 (1.6 gr/scf).

Emission rates are closely related to incinerator design, method of operation, and composition of the refuse charged. The most important variables are the air flow rate (percent underfire air and percent excess air), refuse composition (ash and moisture contents), grate and furnace type, and chamber temperature.

Velocity of the underfire air most strongly influences particulate emission rate. Increasing the amount of excess air decreases furnace temperature, which in turn reduces the completeness of the combustion and leaves more combustible particulates in the exit gases. Increasing excess air also produces secondary detrimental effects on particulate emissions in that it decreases air residence time in the furnace and results in larger amounts of gases to be cleaned by the control equipment. Increasing the moisture content of the refuse has an effect similar to that of increasing the excess air; both reduce the furnace operating temperature. When high moisture contents are encountered in the incoming refuse, the grate loading rate is normally lowered to maintain acceptable furnace temperatures.

3.3 EMISSION CONTROL METHODS

Wet scrubbing systems and electrostatic precipitators are the most favored techniques for meeting the particulate performance standard. Fabric filters are used to a lesser extent on some new or modified incinerators. Mechanical collectors are not adequate for cleaning incinerator exhaust gases, although some are used as precleaners to reduce the load on the primary control systems by removing particulate matter. Optimizing the combustion process is also considered a method of emission control, although it must be used in conjunction with one of the three high-efficiency control systems.

3.3.1 Electrostatic Precipitators

Electrostatic precipitators installed on incinerators are generally of the single-stage, duct-type with horizontal gas flow. Insulation is normally required on the shell to minimize corrosion due to condensation of gases. Discharge electrodes are of the weighted wire or supported frame types; many collection electrode designs are used. A surface collection area of at least 150 ft^2/1000 acfm is probably needed to meet the performance standard, and this is adequate only when other parameters are optimized. Rappers are of the impact type, either electromagnetic, mechanical, or pneumatic. In addition, water sprays may be installed under the precipitator roof to wash down the electrodes.

Properties of the refuse and temperature of gases entering the precipitator are of prime importance since these parameters affect particle resistivity and hence influence collection efficiency. Significant changes in type of refuse can also affect the electrical resistivity and precipitator performance. For example, burning large amounts of paper products will produce carbon particles which have a low resistivity and are easily re-entrained from the precipitator collection electrodes.

The resistivity of particles, and hence collection efficiency changes with the precipitator operating temperature. The zone of high resistivity extends from about 250 to 500°F for typical particulates, and normally causes reduced collection efficiency. Cooling the incinerator exhaust gases below 250° requires extensive heat exchange or water spray conditioning since final incinerator chamber temperatures are in excess of 1000°F. At temperatures above 500°F, less plate surface is required although a greater volume of gases is handled and the materials of construction are more critical.

Other factors that may affect collection efficiency of an electrostatic precipitator include gas velocity and condition of repair. Design velocities of 3 to 5 ft/sec are commonly used on precipitators. Operating at higher velocities may increase the re-entrainment of fly ash and result in higher particulate emissions. In operation at lower velocities it is often difficult to obtain uniform flow across the precipitator. Additionally, as with most complex instrumentation, the level of maintenance of an electrostatic precipitator also affects its efficiency. A detailed discussion of precipitator applications to municipal incinerators is presented in References 3 and 5.

3.3.2 Scrubbers

Wet scrubbers remove particulates by impaction or interception with water droplets. Although many scrubber designs have been applied to incinerators, only venturi scrubbers have a demonstrated capability of meeting the NSPS.

Water is introduced peripherally at the top of the venturi section. The high velocities through the throat of the venturi disintegrates the water into a mass of fine droplets throughout the gas stream. Downstream from the throat, the cleaned gas decelerates and the particle-bearing droplets agglomerate to a size that is easily separated from the gas stream.

The efficiency of these scrubbers is related to power input, which is indicated by the pressure drop through the venturi. Pressure drops for these units normally range from 15 to 50 inches of water. Water usage rates are typically 10 gallons per 1000 cubic feet of gas.

Venturi scrubbers installed on incinerators humidify and cool the exit gases and therefore produce an obvious steam plume at the stack under most atmospheric conditions.

3.3.3 Fabric Filters

The limited number of filter applications on incinerators have all used silicone-treated glass bags to withstand the high temperatures. Bag lives of 1 to 3 years have been reported. Measured control efficiencies have ranged from 98 to greater than 99 percent; maximum pressure losses have ranged from 3 to 7 inches of water; and air-to-cloth ratios (filter velocities) have ranged from 2 to 4 ft/min.

Fabric filters are most sensitive to operating temperature. The maximum satisfactory range of gas temperature is 250 to 550°F; this range may be much narrower for certain bag fabrics and exhaust gas compositions. Temperatures above 500°F cause damage to the silicone coating, accelerated deterioration of the bag, and distortion of the metal frame within the bag. At temperatures below 300°F, condensation and caking usually lead to blinding and bag failure. The installation should be protected against extreme temperatures by an emergency bypass and by sealing against in-leakage of cool air.

All free moisture (entrained droplets or moist fly ash) should be removed from the gas stream before it enters the baghouse to prevent blinding of the filter. Since the incinerator off-gases are commonly cooled to an acceptable inlet temperature by water spray, sufficient residence time must be available following the gas cooling for complete evaporation before the gases reach the fabric filter.

REFERENCES FOR CHAPTER 3

1. Danielson, J.A. Air Pollution Engineering Manual. DHEW. Springfield, Virginia. NTIS No. PB 190-243. 1967.

2. DeMarco, J., et al. Incinerator Guidelines - 1969. U.S. DHEW Bureau of Solid Waste Management, Washington, D.C. PHS Publication No. 2012. 1969, 98 pages.

3. Neissen, W., et al. Systems Study of Air Pollution from Municipal Incinerators. A.D. Little, Springfield, Virginia. NTIS No. APTD 1283, 1284, 1285.

4. Stear, J.R. Municipal Incineration: A Review of Literature. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. Publication No. AP-79.

5. Oglesby, S., and G. B. Nichols. A Manual of Electrostatic Precipitator Technology, NSPCA Contract CPA 22-69-73, 1970.

4.0 INSTRUMENTATION, RECORDS, AND REPORTS

This section is designed to familiarize the inspector with emission-related instrumentation, commonly encountered in process operation, emission controls, and emission monitoring. The type, purpose, location of each instrument and importance to the field inspector are considered briefly; detailed theoretical principles of instrument operations are available from other literature sources.[1,2]

4.1 PROCESS INSTRUMENTATION

The monitoring and process control systems used on municipal incinerators are relatively simple in comparison with instrumentation used on other combustion units. The process instrumentation described below represent the full array of existing systems; some modified installations may lack one or more of the control systems or may incorporate a simpler system in its place.

Underfire/Overfire Draft Gages

Uncontrolled incinerator emissions greatly depend upon the ratio of underfire to overfire air and on the quantities of both. The volume of underfire air should be approximately one-half of the overfire air, although incinerators have successfully burned refuse using different ratios. New incinerators use instrumentation to measure draft pressures in the underfire and overfire air ducts. Some incinerators may also have orifice plates or other air flow measuring devices in the air supply ducts. For such installations, manometers and inclined water gage draft readouts would be close to the incoming air supply. Diaphragm-actuated sensors would be used where remote readouts are desired, as on a centrally located control panel.

The inspector may compare the air flow readings at the time of the acceptable performance with those of subsequent inspections. However, as previously discussed, actual air flow and the ratio of overfire to underfire air will change depending upon refuse composition, particularly moisture. Therefore the inspector must consider the air flow reading in light of other process operating conditions. By so doing, he will be able to determine whether the changed air flow rates are justifiable (e.g., wet refuse) or the incinerator is being operated improperly, either through negligence or deliberately (e.g., grossly exceeding design charging rates).

Flue Gas Concentrations

The amounts of O_2, CO_2 and CO in the exhaust gas provide a direct measure of the excess air rate. Excess air is significant because most control device efficiencies are affected by changes in air flow. In addition, the particulate standard of 0.18 g/NM^3 also stipulates 12 percent CO_2 in the gas stream.

Excess air is determined by the following equations:

$$N_2 + CO_2 + CO + O_2 = 100$$

$$\% \text{ Excess Air} = 100 \times \frac{(O_2 - 0.5\ CO)}{0.264N_2 - (O_2 - 0.5\ CO)}$$

where N_2, CO_2, CO, and O_2 are percents by volume in the gas stream.

Many new or modified incinerators do not incorporate all three monitoring instruments. In such cases, the inspector can only compare the gas values with those obtained in previous inspections. The analyzers actuate remotely mounted recorders, which read directly in percent CO, CO_2, or O_2 on the control panel. The O_2 analyzer may be used as an automatic control unit to maintain constant oxygen content by trimming inlet vanes in the forced-draft fan.

Values for oxygen, CO_2, and CO should be recorded only during an inspection; records of these values by incinerator personnel are unnecessary except during a malfunction.

Temperature

Temperature (including actual flame temperature) may be measured at one or more locations in the ignition chamber, in the secondary combustion chamber or at the furnace exit, prior to and after conditioning, before the air pollution control equipment, and between the control equipment and the stack. The recommended secondary chamber temperature is 1600°F, and temperatures below 1300°F usually result in high particulate emissions.

The inspector is interested in the secondary chamber temperature because of its effect on uncontrolled emissions. He should also note the position of the thermocouple into the furnace. Temperatures are recorded on circular or strip charts located on the control panel. Charts can be dated and kept for inspection.

Scales

Refuse delivered to the incinerator is weighed on truck scales before being dumped into the storage pit. Because the pit is a discontinuity in the process, the recorded scale weights per unit time are not directly related to the charging rate; total scale weights recorded over extended periods, however, do indicate the average charging rate. The truck scales give the only measurement of the weight of refuse processed.

Records of incoming weights are compiled at the weigh station, along with such auxiliary information as name of the hauler, origin of the refuse, and composition of the load. These records are normally totaled by day and by week.

Charging Rate

One method of calculating the charging rate is to consider the rate of grate movement, grate area, and height of refuse on the grates. An inspector cannot take representative data during a brief inspection, since these variables are valid only if they are considered over a long time period. Pre-weighed refuse is charged during a performance test. For subsequent inspections, records of the amount of refuse charged and the hours of operation by furnace yield a more integral charging rate than that provided by calculating grate movement and bed height. Charging rates should not exceed 50 lb/ft^2-hr, unless the incinerator is specifically designed to handle higher quantities of refuse.

4.2 CONTROL DEVICE INSTRUMENTATION

The inspector should collect initial control device data when NSPS tests are performed. Comparison with data from later inspections should indicate whether the source complies with particulate standards without further emission testing.

Electrostatic Precipitators

The inspector should record voltage, current, and spark rates from instrument gages usually located in the immediate vicinity of the precipitator. Proper adjustment of the electrical input to the precipitator is required to obtain maximum performance. Voltage-current characteristics of the precipitator depend upon dust concentration, and particle size and resistivity.

A transformer converts incoming "primary" voltage (220 or 440 volts) to the "secondary" voltage (kilovolts) required by the precipitator unit. Secondary current and voltage readouts are in mA and kV, respectively. Gages may record primary or secondary voltages and currents, or both.

The spark rate meter is calibrated in sparks per minute. Low spark rates may result from broken wires (discharge electrodes), an inadequate precipitator power supply, or a precipitator which is not designed to operate under a spark rate limited condition. Each section of precipitators has its own instrumentation and the inspector must record values from all sections.

The inspector must check temperature gages (if they exist) upstream of the precipitator. Hot exhaust gases from the secondary chamber must be cooled prior to entering the precipitator. Inadequate cooling results in excessive gas flow volumes and ultimately in higher particulate emissions.

Scrubbers

When inspecting venturi scrubbers, the inspector should check water rates from flow meters located on the main control panel.

The inspector is concerned with the pressure differential across the scrubber. Pressures can be read either from manometers directly attached to the scrubber or from gages located on the instrument panel.

Fabric Filters

The inspector is interested in the inlet temperature and the pressure drop across the bags. Manometers or pressure gages are located either on the baghouse or the control panel. Low pressure drop indicates that the gas stream is inefficiently cleaned by torn or otherwise defective bags.

4.3 FACILITY RECORDKEEPING REQUIREMENTS

The NSPS for incinerators require only that the daily burning rates and hours of operation be routinely recorded. These two values should be entered daily for each incinerator unit in a logbook similar to that shown in Figure 4.1. This format permits compilation and checking of monthly summary data. The logged data and monthly summaries must be retained by the operator for at least two years.

The general NSPS provisions also require that the operator report each quarter all start-ups, shutdowns, and malfunctions that result in emissions higher than the particulate standard; these records also must be maintained for a two year period. Since start-ups and shutdowns are common at most incinerators and are not normally associated with extremely high emission rates, the operator may find it efficient to combine records of start-ups and shutdowns with the log of daily operations. This has been done in the example in Figure 4.1.

It is recommended that a separate record be kept of the less frequent, but more critical occurrences of malfunctions requiring reporting. This record should, as a minimum, document the duration of each malfunction and actions taken to minimize increased emissions. A sample format for recording occurrences of malfunctions is presented in Figure 4.2.

If opacity instrumentation is used to monitor particulate matter, strip charts or graphs should be dated and calibration records kept in the event they would be used to verify pollutant levels.

Although not presently required by NSPS, records of important process parameters should be kept for at least a two year period. These include secondary combustion chamber temperature and control device parameters such as spark rate, and secondary current and voltage for precipitators or pressure drop for scrubbers.

4.4 REPORTING PROCEDURES

The NSPS specify that the facility operator must maintain certain records for a period of two years. No periodic submittal of data or of data summaries is required, however.

The operator must furnish written notification to EPA of the anticipated date of initial start-up, the actual date of start-up, and the date for conduct of the performance test. In addition, he must provide a written report of performance test results. It shall include weights of particulate collected in each of the three repetitive tests, sample air volumes, times of tests, percents CO_2, incinerator charging rates, and the calculated emission rates for each of the three tests. A suggested format for the test report appears in Appendix B.

The operator of the incinerator may also be required to provide other information to EPA or the state agency under separate regulations. This may include information required in application for a permit to operate the new facility or information needed for completion of the semi-annual report on new emission sources as part of implementation plan requirements.

RECORD OF INCINERATOR OPERATION AND BURNING RATE

MONTH __________ YEAR __________

DATE	UNIT 1					UNIT 2				
	HOURS OF OPERATION	CHARGING RATE, T/HR*	TOTAL BURNED T/DAY	STARTUP(U)OR SHUTDOWN(D) TIME	REASON	HOURS OF OPERATION	CHARGING RATE, T/HR*	TOTAL BURNED T/DAY	STARTUP(U)OR SHUTDOWN(D) TIME	REASON
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
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22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
Total for Month										
Av. Burning Rate										
Max. Daily Burning Rate										

* How Determined? ______________________________

Figure 4.1 Example log for recording and summarizing incinerator operation.

RECORD OF MALFUNCTIONS

UNIT	DATE & TIME OF MALFUNCTION	NATURE	MEANS OF CORRECTION	DATE & TIME CORRECTED	DURATION	EFFECT ON EMISSIONS	ACTIONS TAKEN TO MINIMIZE

Figure 4.2 Example log for recording incinerator malfunctions.

4.5 SUMMARY

A summary of all instrumentation and records is tabulated in Table 4.1.

Table 4.1 SUMMARY OF INCINERATOR INSTRUMENTATION AND RECORDKEEPING

Item	Read off gage	Values recorded by facility	Charts dated by facility
Secondary chamber temperature	X		X
Scales/daily burning rates[a]		X	
Electrostatic precipitator			
Spark rate	X	X	
Power	X	X	
Upstream duct temperature	X		
Scrubber pressure drop	X	X	
Baghouse pressure drop	X	X	
Opacity	X		X
Malfunctions[a]		X	
Hours of operation[a]		X	

[a] Required by NSPS

REFERENCES FOR CHAPTER 4

1. Considine, D.M. Process Instrumentation. Chemical Engineering. p 84-113, January 29, 1968.

2. Meffert, D.P., M.M. McEven, and R.H. Gilbreath, Jr. Stack Testing and Monitoring. Pollution Engineering. 5:6:25-33.

5.0 START-UP/MALFUNCTIONS/SHUTDOWN

5.1 START-UP

The interior of a municipal incinerator must be protected during start-up as incinerator temperatures climb from ambient to the operating level of between 1800 and 2500°F. Because the refractory material has strong insulating properties, it resists temperature changes and thereby is subjected to great internal stresses if the incinerator is brought to operating temperature too rapidly. This results in spalling and premature failure. The grate system and other interior parts suffer similar effects.

Therefore, start-up of a municipal incinerator is usually a 2- to 4-hour procedure in which the refuse loading and the airflow are gradually increased, and during which time the furnace temperatures are intentionally controlled below the levels required for optimum combustion. The initial charging rate normally varies from one-third to one-half of the design rate and is increased stepwise over the duration of the start-up period.

A well-maintained, continuously running municipal incinerator starting up in the beginning of the week should be able to run through the week without shutting down. Batch incinerators that must be started each day or several times per week spend a significant percent of their total operating time under non-optimum start-up conditions, i.e. with poor combustion and reduced charging capacity.

The effect of start-up on emission rate is an increase, primarily in the combustible particulate, as a result of incomplete combustion. This increase is usually not obvious, however, since the incinerator is operating at only a fraction of its full charging rate. Emissions in lb/hr, instead of the g/NM^3 of the performance test, may actually be lower than during normal operation.

The higher emission rates at start-up are not readily reduced or minimized by process changes, because they result from low temperatures and the low temperatures are required for safe start-up. The percent excess air or amount of overfire air cannot be increased substantially from normal levels to obtain complete combustion because of their further dampening effect on temperatures. Incinerators covered by NSPS cannot effectively use auxiliary fuel on start-up to reduce emissions.

Wet refuse, although not defined as a malfunction, often results in incomplete burning and high emissions. Instrumentation indicates this as chamber temperatures decline and overfire/underfire draft ratios decrease. The enforcement officer should bear in mind that incinerator inspection the day (or possibly two) after a rainstorm are not indicative of normal operation.

5.2 MALFUNCTIONS

Incinerator malfunctions are frequent because of the nature and composition of refuse. Large or sharp objects can damage the grates, and refuse of high moisture content can corrode downstream equipment. A multitude of malfunctions are possible; the more common ones are summarized in Table 5.1.

If malfunctions occur repeatedly, the inspector should determine what corrective actions be taken to reduce their frequency. The impact of malfunctions may be minimized by changing incinerator design, improving maintenance procedures, and stocking more spare-parts.

5.3 SHUTDOWN

The shutdown of an incinerator does not involve operations that significantly increase emissions. Charging is discontinued, but grate movement, airflow, and operation of the air pollution control system continue until all the refuse in the furnace has been burned. Heat retained by the refractory and other interior parts keeps temperatures at acceptable levels for the 1 to 2 hours required to completely burn out the refuse after charging has been discontinued.

Table 5.1 INCINERATOR MALFUNCTIONS WHICH AFFECT EMISSION RATES

Malfunction	Frequency of occurrence	Duration	Effect on emission rate	Means to minimize excess emissions
Damage to grate[a]	Depends upon maintenance and care used in charging procedures.	Unit repaired at next shutdown.	Minor unless severe damage.	
Breakdown of flue gas cooling system	Infrequent	About one hour until incinerator can be brought off-line.	Requires bypassing of emission controls.	Immediately curtail refuse charging operations.
Excessive air infiltration	-	Results from poor maintenance and will continue until corrected.	Dependent upon amount of air and location.	Usually results from long term negligence of maintenance.
Plugged air ports	Infrequent	1 or 2 days.	May be substantial.	Air flow redistribution by dampers.
Precipitators	Several times/year for well maintained unit; can be higher if unit is poorly designed or maintained.		Varies but can be substantial.	Reduce gas flow volume to precipitation (i.e., reduce charging rate); have spare parts available.
plugged spray nozzles		6 to 8 hours.		
frozen rapping systems		Minimum of 4 hours		
broken or dirty electrodes		Varies		
ESP section out		ESP can usually be repaired in a few hours.		
Bag failures	Average occurrence about once per month.	1 to 4 hours	Air contaminants will be uncontrolled in the gas stream going through the broken bags.	Check bags periodically for minute leaks and work fabric.

[a] Reciprocating grates frequently become so clogged that the incinerator will be shut down for grate repair and cleanout. These shutdowns are usually planned, and are not considered malfunctions.

6.0 PERFORMANCE TESTS

Section 6.1 describes the operating conditions to be established in preparation for performance tests. Later sections discuss observations of the facility and evaluation of source test procedures. The final section provides a checklist of process and test parameters to be recorded during the performance test.

6.1 PRETEST PROCEDURES

Although the new source performance standards stipulate exact procedures for compliance, facility personnel may misunderstand or not be aware of parts of the regulations. The inspector should therefore arrange a meeting with plant personnel to review details of the standards and the testing procedures prior to the actual performance test. The inspector provides copies of the performance standards at the meeting.

Since a new municipal incinerator facility may contain more than one furnace, it is necessary to identify the furnace or furnaces being tested. The enforcement officer should request a plot plan of the facility and properly identify the particular furnace on all inspection checklists.

The inspector should determine which testing firm is to perform the tests, and if no representative of the firm attends the meeting, contact the firm to ensure that tests are run in accordance with procedures outlined in 40 CFR 60. The chief purpose of the pretest meeting is to outline clearly for all concerned parties the purpose of the tests and the required test procedures. The inspector must also survey the ductwork for test port locations. If satisfactory sites are not available, he should suggest modifications (e.g. stack extensions, flow straighteners) needed to obtain accurate test results. The location of a clean-up area should be agreed upon by all parties prior to the test date. During a tour of the incinerator, the inspector determines whether additional inspection personnel are required to monitor the process sampling site, and exhaust stack.

Three operating conditions must be established and approved by the inspector prior to performance testing:

- charging rate
- composition of refuse
- incinerator and control equipment operation

Charging Rate - The NSPS require that the charging rate during performance testing be at representative performance. This rate may be estimated as the design capacity for an incinerator just beginning operation. Experience has shown, however, that actual maximum charging rates at incinerators that have been in operation for several years frequently exceed the design rate by 20 to 30 percent. If a unit is performance tested at a specific capacity and later is operated at higher charging rates, it must be retested. The inspector must therefore stress the desirability of initially testing at the highest loading rate anticipated.

Records of the exact quantity of refuse burned during the performance test are important for future comparisons. For the performance test, refuse piles of weight (determined by truck scales) equal to the desired charging rate for a two hour test period are set aside in the pit area. These piles are then loaded into the charging hopper at a uniform rate that depletes each pile over the two hour test period. This relatively crude procedure affords several opportunities for error including:

- All the refuse in the pile must be picked up by the crane and charged; and
- Refuse in the charging hopper at the beginning and end of the test period may lead to an inaccurate estimate of the charging rate.

The inspector can easily witness several truck weighings prior to testing to ensure that refuse weights are valid. He should determine whether the scales were calibrated and when. If the scales were not calibrated, the tests should not be considered valid.

Composition of Refuse - The NSPS state that the refuse burned during the performance test should be representative of normal operation. The refuse is generally preselected from truckloads entering prior to the testing; observing the character of the incoming refuse in a number of trucks and then carefully selecting truck loads of refuse for the test can produce a representative sample. On the other hand, a biased refuse sample which reduces incinerator emissions can be assembled either intentionally or unintentionally. For these reasons, the inspector must participate with incinerator personnel in selecting the refuse to be burned during the performance test.

The facility should be tested while burning dry refuse (i.e,, not refuse which has a high moisture content due to recent rain). This will permit the facility to operate at its highest charging rate.

Incinerator and Control Equipment Operation - Incinerator parameters influencing particulate emissions were described in Sections 3 and 4. Maximum or minimum values, as described below, should be established for the following parameters in order that the facility may operate at either higher or lower values and not be suspected of violating the particulate emission standard.

- Secondary chamber temperature - The facility should be tested with the secondary chamber temperature at the minimum value the plant contends is satisfactory and anticipates operating at.

- Underfire air - The facility should be tested when operating with the highest underfire air rate anticipated for the type of refuse being burned (preferably dry).

- Electrostatic precipitator sections operating - If an electrostatic precipitator is used, it may have been designed to achieve the required level of particulate removal with one or more sections not in operation (to preclude the necessity of curtailing incinerator operation when a section malfunctions). Precipitators can be "fine tuned" for purposes of passing a performance test but be incapable of sustained operation at this level of efficiency. Thus the precipitator should be operating without manual adjustments of voltage, current input, etc., preferably for a minimum of one month. (Some purchasers are now requiring that precipitators be performance tested after operating for one year without any adjustments other than routine maintenance.

- Scrubber pressure drop and scrubbing liquor flow rate - The scrubber should be operated at the minimum pressure drop and liquor flow rate that are anticipated under routine full-load operation.

Operation of the incinerator should be in equilibrium prior to testing. The incinerator should be running at the desired load for at least three hours before emission tests are started. Process data must be recorded during the stabilization period to ensure that the incinerator is in equilibrium during the performance runs.

6.2 PROCESS OBSERVATION

Important process and emission control device operating conditions should be recorded during the compliance test for future comparisons. These observations provide a baseline for comparison with operating conditions observed during later inspections. The observations also indicate reasons for excessive particulate emissions if the source fails to meet NSPS. These parameters are listed in Table 6.1, which includes comments about the expected observations, source of readings, and frequency of observance.

In the event an upset occurs during a test, the run may be void, depending on the severity of the malfunction. A precipitator power loss or frozen refuse charging hardware will produce a particulate sample which is not representative of normal operating conditions. These are examples of upsets that require a rerun of emission tests.

Many upsets will not endanger the portion of the sample prior to the abnormal operation. In this case, the sample train can be withdrawn from the sampling port with the pump turned off until normal conditions prevail.

6.3 EMISSION TEST OBSERVATIONS

Particulate tests and opacity determinations are conducted by qualified emission testing personnel. The inspector is responsible for ensuring that all pertinent data are collected, that the field procedures and equipment meets CFR, and that the incinerator is run at representative performance during all sampling runs.

The NSPS require three 1-hour particulate tests performed at representative performance conditions. Gas analysis is required to express particulate emissions corrected to 12 percent CO_2.

As a rule, the inspector's surveillance of the test crew depends upon his knowledge of their competence. He should, however, be aware of a few major items:

- Record duct dimensions (both inside and outside) and location of sample ports.
- Check the number of ports at the sampling site and examine the ducting for the nearest upstream and downstream obstructions. Ask the crew leader how many total points will be traversed and check with Figure 1.1 in 40 CFR 60 to determine whether the stream will be properly sampled.
- Note whether the crew runs a preliminary traverse, and if so, inquire what nozzle diameter is selected. (Isokinetic sampling is a function of nozzle size.)

Table 6.1 INCINERATOR OPERATING CONDITIONS WHICH AFFECT EMISSIONS

Observation	Location	Comments
INCINERATOR		
Secondary chamber temperature	Control panel gage	Note thermocouple location in combustion chamber. Record values every 20 minutes
Flue gas concentration (CO_2, CO, O_2)	Control panel gage	
Underfire air draft	Control panel gage	Many incinerators do not monitor overfire and underfire air draft. Record every 20 minutes
Overfire air draft	Control panel gage	
Grate speed	Control panel gage	Record every 20 minutes
Crane weight sensors	Loading area	Record every 20 minutes
CONTROL DEVICE		
Control device entry temperature	Control panel gage	Record twice per performance test
Electrostatic precipitator		
Spark rate/section	Meter on precipitator control panel	Record twice per performance test
Voltage/section	Meter on precipitator control panel	Record twice per performance test
Current/section	Meter on precipitator control panel	Record twice per performance test
Scrubber		
Water rate	Ask operator	Record twice per performance test
Pressure drop	Control panel gage or manometer on scrubber	Record twice per performance test
Baghouse		
Pressure drop	Control panel gage	Record twice per performance test

- Check to ensure that the moisture content of the gas stream is determined by Method 4 or an equivalent method such as drying tubes or volumetric condensers; assumption of the moisture content is not allowed.

- Observe the leak test of the sampling train. The allowable leak rate is given in Method 5. Leakage results in lower concentrations than are actually present. Be next to the dry gas meter during the leak check, note whether the meter hand is moving. (The more the hand is moving, the greater the air leakage.) Leak checks must also be made if the train is disassembled during the run to change a filter or to replace any component.

- Record dry gas meter readings before and after test.

- Record average velocity head and temperatures in ducts during tests.

- If impingers are used during test, observe whether they are bubbling. If they are not, the sampling train is either plugged or disconnected from the pump.

- Check the cleaning procedure for the front half of the train. Careless removal of filters or cleaning of probes will result in lower calculated emissions. Look for broken glass from probes or connectors. Test is void if glass probe was broken during test. If glass connectors are broken in transport from sampling site to clean-up area, test is still valid. Make sure identification labels are attached properly to collection containers. The probe should be brushed and rinsed with acetone thoroughly to remove all particulates. The probe should be visually inspected after cleaning to ascertain that all particulates have been removed.

- Observe gas analysis procedure for determining CO_2. Gas samples must be taken simultaneously with particulate runs. Variations greater than 0.5 percent (grab sample) or 0.2 percent (integrated sample) indicate gas mixture was not thoroughly bubbled through reagents. Ask sampling crew when new reagents were added to apparatus.

- Check percent isokinetic.

- Determine calibration dates and procedures used to calibrate pitot tube, thermometer, dry gas meter, and manometer orifice.

- Record process parameters during emission tests and opacity readings.

6.4 PERFORMANCE TEST CHECKLIST

The inspector must observe incinerator operation and emission tests simultaneously to ensure that valid data are used in determining plant performance. He should also complete a performance test checklist as indicated in Table 6.2. If the inspector observes any additional parameters recorded by the plant that are directly related to emissions, they should also be recorded.

In the event of a malfunction or upset, the enforcement officer must inform the test crew leader that the sampling trains are to be shut off and removed from the ducts as quickly as possible. If process changes or deviations occur, the inspector is responsible for instructing sampling personnel whether to proceed with the run or temporarily stop the test.

The enforcement officer keeps a log of any abnormal operation, time of occurance, and return to representative conditions. After reviewing emission test results, he can decide whether the run is valid.

According to 60.8(a) of 40 CFR 60, incinerator management is responsible for furnishing the Environmental Protection Agency a written report of the results of the emission tests. Appendix B provides a suggested format for the report. These reports should be carefully checked and the data compared with values on the inspection checklist.

Table 6.2

NSPS INSPECTION CHECKLIST FOR MUNICIPAL INCINERATORS DURING PERFORMANCE TEST

Facility Name ______________________________

Facility Address ______________________________

Name of Plant Contact ______________________________

Source Code Number ______________________________

Unit Identification (To Be Tested) ______________________________

Design Charge Rate ______________ tons/day

Actual Charge Rate ______________ tons/day

Initial Start-Up Date ______________________________

Continuous Operation Date ______________________________

Test Date ______________________________

A. INCINERATOR CHARACTERISTICS

Charging Method ☐ Batch
☐ Continuous

Operating Schedule ____hr/day ____ days/wk ____wk/yr

Approximate Grate area ____ ft^2

APC Device Type

☐ Scrubber
☐ ESP
☐ Fabric Filter

B. REFUSE PREPARATION

Refuse Weight Determination

☐ Truck Scales
☐ Manual Weighing
☐ Other ______________________________

Refuse Composition Determination (EPA Method) ☐ Yes ☐ No

Moisture Content (Estimate) ☐ Satisfactory ☐ High ☐ Low

Precharge Preparation

☐ Shredder
☐ Metal Extractor
☐ Other ______________________________

Table 6.2 (continued). NSPS INSPECTION CHECKLIST FOR MUNICIPAL INCINERATORS DURING PERFORMANCE TEST

C. INSTRUMENTATION DATA

ITEM	UNITS	VALUES[a]				
Secondary Chamber Temp.	°F					
APC Device Entry Temp.	°F					
Overfire Air Draft	in. H_2O					
Underfire Air Draft	in. H_2O					
Grate Speed	indicate units					
Refuse Measuring Sensors	indicate units					
O_2	%					
CO_2	%					
CO	%					
Opacity Monitor	%					
Precipitator						
Spark Rate	sparks/min					
Secondary Voltage	kV					
Section No.						
Section No.						
Section No.						
Section No.						
Section No.						
Section No.						
Secondary Current	mA					
Section No.						
Section No.						
Section No.						
Section No.						
Section No.						
Section No.						
Scrubber						
Water Rate	gal./min					
Pressure Drop	in. H_2O					

[a] See Section 6.2 for recommended frequency of recorded values.

Table 6.2 (continued). NSPS INSPECTION CHECKLIST FOR MUNICIPAL INCINERATORS DURING PERFORMANCE TEST

D. PRETEST DATA (OBTAIN FROM TEST TEAM FIELD LEADER)

Test Company____

Field Leader____

Duct Dimensions______in. x______in;   Area______ft^2

Nearest Upstream Obstruction______________________ft

Nearest Downstream Obstruction____________________ft

No. of Sampling Ports_____________________________

No. of Sampling Points____________________________

No. of Sampling Points Required from Figure 1.1 in 40 CFR 60____________________

E. PARTICULATE PERFORMANCE TEST

Test No.____________Start Time____________Finish Time____________

	Yes	No
Preliminary Traverse Run (Method 1) Chosen Nozzle Diameter______in.	☐	☐
Train Leak Check	☐	☐
Moisture Determination (Method 4) Moisture Content_____% ml Collected/Gas Volume_____ml_____ft^3	☐	☐

Combustion Gas Analysis O_2_____%

CO_2_____%

CO_____%

Dry Gas Meter Reading Before Test_____ft^3 @_______(time)

Dry Gas Meter Reading After Test______ft^3 @_______(time)

Volume Sampled ______ft^3

Test Duration_________________________________minutes

Average of Meter Orifice Pressure Drop____________inches

Average Duct Temperature__________________________°F

Table 6.2 (continued). NSPS INSPECTION CHECKLIST FOR MUNICIPAL INCINERATORS DURING PERFORMANCE TEST

Velocity Head at Sampling Point ________ inches H_2O

Meter ΔH@* ________

Repetition Start Time ________

Repetition Finish Time ________

F. CLEANUP PROCEDURE

Filter Condition	☐ Dry		☐ Wet
Probe Status	☐ Unbroken		☐ Broken
Glass Connectors	☐ Unbroken		☐ Broken
Cleanup Sample Spillage	☐ None	☐ Slight	☐ Major
Sample Bottle Identification	☐ Yes		☐ No
Acetone Blank Taken	☐ Yes		☐ No

7.0 INSPECTION PROCEDURES

Periodic visits will enable the inspector to determine the status of the plant's emission controls. Comparison of operating parameters observed during inspection with those recorded in the performance test should indicate whether emissions are within allowable limits. This section describes inspection procedures, including completion of a checklist, and recommended follow-up procedures.

7.1 PROCEDURES FOR PERIODIC INSPECTION

The frequency of inspections is governed by agency policy. A quarterly inspection is recommended unless complaints dictate more frequent inspections.

Major emphasis of the inspection is placed upon checking facility records and observing process and control equipment operation, including instrumentation. The inspector compares records of operating hours and refuse receipts to charging rates recorded in the performance test. Control device and process instrumentation give an indication of particulate emissions.

The following procedures should be performed in the order shown whenever possible. The suggested format enables the inspector to tour the plant, observe the process, and monitor the instruments during actual operation. He can then investigate any questionable areas by looking at records and conferring with the incinerator operator.

OBSERVATIONS OUTSIDE THE PLANT

- Note plume opacity.
- Check whether truck scales are properly operating.

CONTROL EQUIPMENT

- Read pertinent gages on scrubber, precipitator, or baghouse. Compare with values obtained during performance test.

CONTROL PANEL

- Read pertinent air flow gages, temperatures, and combustion gas meters.

INCINERATOR

- Observe charge procedure for even distribution of refuse into chutes. Check refuse level in chutes and rate of air leaks into primary combustion chamber.

- Look into furnace ports if possible. Examine grates for possible missing sections. Observe refuse bed lumps or blowholes. Exercise extreme caution when looking into the furnace. Always wear eye and face protection since exploding containers can cause serious injury. Always let the incinerator operator open furnace doors and ports; never do so yourself or manipulate any furnace controls.

- Note ash removal from chamber. Ash should be quickly removed and water quenched to avoid entrainment of fly ash into gas stream.

RECORDS

- Review record of hours of operation, daily collection, and charging rate (if available).

- Examine dated charts of temperature measurements.

- Check truck scale and control device maintenance.

7.2 INSPECTION CHECKLIST

The inspection form included as Table 7.1 is derived from the procedures described above.

7.3 INSPECTION FOLLOW-UP PROCEDURES

Some agencies have regulatory jurisdiction over pollutants not covered by NSPS (e.g., odors, fugitive dust). These agencies may wish to incorporate inspection procedures covering such pollutants into the NSPS format for periodic inspections.

If, upon completion of his tour of the plant, the inspector believes that a citation is warranted, he must state clearly the grounds for citation. An on-site citation is justified only by clear-cut violations, such as excessive opacity, or by failure of the plant operator to maintain or provide required records.

Before leaving the plant, the inspector should also compare the values he has recorded on the checklist with data from earlier inspections or from the performance tests. Although compliance sometimes cannot be determined without a source test, the checklist should provide enough information to indicate whether emissions may be excessive. A comparison format for determining compliance status is given in Table 7.2. If current values exceed the range of variation indicated in the table, a possible violation of source performance standards is indicated. The inspector should notify the responsible incinerator plant official and confirm this in writing, giving data that indicate the possible violations. Resolution of such a matter usually entails the setting of a test date and follow-up inspection.

Because plant inspection can be the function of a Federal, state, or local agency, systematic communication among agencies is required to prevent duplication of effort and to ensure that all concerned parties are aware of the current status of municipal incinerator operations. It is important, therefore, that post-inspection procedures incorporate a mechanism for notifying all concerned agencies of any changes in compliance status or other significant action.

Table 7.1

NSPS INSPECTION CHECKLIST FOR MUNICIPAL INCINERATORS AFTER PERFORMANCE TEST

Facility Name ______________________________

Facility Address ______________________________

Name of Plant Contact ______________________________

Source Code Number ______________________________

Unit Designation ______________________________

Design Charge Rate ______________________________

Actual Charge Rate ______________________________

Inspection Date ______________________________

A. PRE-ENTRY OBSERVATIONS Time __________

Stack Plume (Use EPA Plume Observation Procedures)

Opacity Regulation ☐ In Compliance
☐ Not In Compliance

Weigh Scales ☐ Operating ☐ Not Operating

Trucks Weighed and Recorded Before Dump ☐ Yes ☐ No

Trucks Weighed and Recorded After Dump ☐ Yes ☐ No

B. CONTROL EQUIPMENT

1) Electrostatic Precipitator

Section					
Primary Current, amps					
Primary Voltage, volts					
Secondary Current, mA					
Second Voltage, kV					
Spark Rate, spk/min					

2) Scrubber

Module					
Liquid Flow, gal./min.					
Pressure Across Scrubber, in. H_2O					

Table 7.1 (continued). NSPS INSPECTION CHECKLIST FOR MUNICIPAL INCINERATORS AFTER PERFORMANCE TEST

3) Fabric Filter

Compartment	
Pressure Drop Across Fabric Filter, in. H_2O	

Additional Observations:

C. CONTROL PANEL Time__________

Secondary Chamber Temp. _______ °F

APC Device Entry Temp. _______ °F

Underfire Air Draft _______ in. H_2O

Overfire Air Draft _______ in. H_2O

O_2 Analyzer _______ %

CO_2 Analyzer _______ %

CO Analyzer _______ %

Grate Speed __________ (indicate units)

Refuse Measuring Sensors __________ (indicate units)

D. INCINERATOR Time__________

	Satisfactory	Unsatisfactory
Charge Cranes	☐	☐
Furnace Grates (if visible)	☐	☐
Residue Removal System (including quenching)	☐	☐

E. RECORDS

Temperature Charts (Dated and Filed by Incinerator Personnel)

	Satisfactory	Unsatisfactory
Secondary Chamber	☐	☐
APC Device Entry Gas	☐	☐

Hours of Operation__________________________

Charging Rate, T/hr__________________________

Daily Collection, T/day______________________

Table 7.2 PARAMETER COMPARISON TO DETERMINE COMPLIANCE STATUS

Parameter	Category[a]	Deviation from performance test values, percent
Weigh scales out of operation	1	---
Collection and burning records not kept	1	---
ESP power input (current and voltage)	2	<30
ESP spark rate	2	<40
Scrubber liquid flow	2	<40
Scrubber pressure drop	2	<20
Baghouse pressure drop	2	<20
Secondary chamber temperature	3	<20
APC device inlet temperature	3	<20
Gas analyzers	3	±50

a) 1. Parameter for which citation can be issued if source is not in compliance.

2. Parameter which gives strong indication that emissions are out of compliance. Value out of indicated ranges is justification for emission test.

3. Parameter cannot be directly used to justify emission test but can be used to support conclusions.

APPENDIX A

STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES CODE OF FEDERAL REGULATIONS

Chapter 1 - Environmental Protection Agency

SUBCHAPTER C - AIR PROGRAMS

PART 60 - STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES

Subpart A - General Provisions

§60.1 Applicability.

The provisions of this part apply to the owner or operator of any stationary source which contains an affected facility the construction or modification of which is commenced after the date of publication in this part of any standard (or, if earlier, the date of publication of any proposed standard) applicable to such facility.

§60.2 Definitions.

As used in this part, all terms not defined herein shall have the meaning given them in the Act:

(a) "Act" means the Clean Air Act (42 U.S.C. 1857 et seq., as amended by Public Law 91-604, 84 Stat. 1676).

(b) "Administrator" means the Administrator of the Environmental Protection Agency or his authorized representative.

(c) "Standard" means a standard of performance proposed or promulgated under this part.

(d) "Stationary source" means any building, structure, facility, or installation which emits or may emit any air pollutant.

(e) "Affected facility" means, with reference to a stationary source, any apparatus to which a standard is applicable.

(f) "Owner or operator" means any person who owns, leases, operates, controls, or supervises an affected facility or a stationary source of which an affected facility is a part.

(g) "Construction" means fabrication, erection, or installation of an affected facility.

(h) "Modification" means any physical change in, or change in the method of operation of, an affected facility which increases the amount of any air pollutant (to which a standard applies) emitted by such facility or which results in the emission of any air pollutant (to which a standard applies) not previously emitted, except that:

(1) Routine maintenance, repair, and replacement shall not be considered physical changes, and

(2) The following shall not be considered a change in the method of operation:

(i) An increase in the production rate, if such increase does not exceed the operating design capacity of the affected facility;

(ii) An increase in hours of operation;

(iii) Use of an alternative fuel or raw material if, prior to the date any standard under this part becomes applicable to such facility, as provided by §60.1, the affected facility is designed to accomodate such alternative use.

(i) "Commenced" means, with respect to the definition of "new source" in section 111(a)(2) of the Act, that an owner or operator has undertaken a continuous program of construction or modification or that an owner or operator has entered into a contractual obligation to undertake and complete, within a reasonable time, a continuous program of construction or modification.

(j) "Opacity" means the degree to which emissions reduce the transmission of light and obscure the view of an object in the background.

(k) "Nitrogen oxides" means all oxides of nitrogen except nitrous oxide, as measured by test methods set forth in this part.

(l) "Standard conditions" means a temperature of 20°C (68°F) and a pressure of 760 mm of Hg (29.92 in. of Hg).

(m) "Proportional sampling" means sampling at a rate that produces a constant ratio of sampling rate to stack gas flow rate.

(n) "Isokinetic sampling" means sampling in which the linear velocity of the gas entering the sampling nozzle is equal to that of the undisturbed gas stream at the sample point.

(o) "Start-up" means the setting in operation of an affected facility for any purpose.

(p) "Shutdown" means the cessation of operation of an affected facility for any purpose.

(q) "Malfunction" means any sudden and unavoidable failure of air pollution control equipment or process equipment or of a process to operate in a normal or usual manner. Failures that are caused entirely or in part by poor maintenance, careless operation, or any other preventable upset condition or preventable equipment breakdown shall not be considered malfunctions.

(r) "Hourly period" means any 60 minute period commencing on the hour.

(s) "Reference method" means any method of sampling and analyzing for an air pollutant as described in Appendix A to this part.

(t) "Equivalent method" means any method of sampling and analyzing for an air pollutant which have been demonstrated to the Administrator's satisfaction to have a consistent and quantitatively known relationship to the reference methods, under specified conditions.

(u) "Alternative method" means any method of sampling and analyzing for an air pollutant which is not a reference or equivalent method but which has been demonstrated to the Administrator's satisfaction to, in specific cases, produce results adequate for his determination of compliance.

(v) "Particulate matter" means any finely divided solid or liquid material, other than uncombined water, as measured by Method 5 of Appendix A to this part or an equivalent or alternative method.

(w) "Run" means the net period of time during which an emission sample is collected. Unless otherwise specified, a run may be either intermittent or continuous within the limits of good engineering practice.

§60.4 Address.

All requests, applications, submittals, and other communications to the Administrator pursuant to this part shall be submitted in duplicate and addressed to the appropriate Regional Office of the Environmental Protection Agency, to the attention of the Director, Enforcement Division.

§60.5 Determination of construction or modification.

When requested to do so by an owner or operator, the Administrator will make a determination of whether actions taken or intended to be taken by such owner or operator constitute construction or modification or the commencement thereof within the meaning of this part.

§60.6 Review of plans.

(a) When requested to do so by an owner or operator, the Administrator will review plans for construction or modification for the purpose of providing technical advice to the owner or operator.

(b)(1) A separate request shall be submitted for each construction or modification project.

(2) Each request shall identify the location of such project, and be accompanied by technical information describing the proposed nature, size, design, and method of

operation of each affected facility involved in such project, including information on any equipment to be used for measurement or control of emissions.

(c) Neither a request for plans review nor advice furnished by the Administrator in response to such request shall (1) relieve an owner or operator of legal responsibility for compliance with any provision of this part or of any applicable State or local requirement, or (2) prevent the Administrator from implementing or enforcing any provision of this part or taking any other action authorized by the Act.

§60.7 Notification and record keeping.

(a) Any owner or operator subject to the provisions of this part shall furnish the Administrator written notification as follows:

(1) A notification of the anticipated date of initial start-up of an affected facility not more than 60 days or less than 30 days prior to such date.

(2) A notification of the actual date of initial start-up of an affected facility within 15 days after such date.

(b) Any owner or operator subject to the provisions of this part shall maintain for a period of 2 years a record of the occurrence and duration of any start-up, shutdown, or malfunction in operation of any affected facility.

(c) A written report of excess emissions as defined in applicable subparts shall be submitted to the Administrator by each owner or operator for each calendar quarter. The report shall include the magnitude of excess emissions as measured by the required monitoring equipment reduced to the units of the applicable standard, the date, and time of commencement and completion of each period of excess emissions. Periods of excess emissions due to start-up, shutdown, and malfunction shall be specifically identified. The nature and cause of any malfunction (if known), the corrective action taken, or preventive measures adopted shall be reported. Each quarterly report is due by the 30th day following the end of the calendar quarter. Reports are not required for any quarter unless there have been periods of excess emissions.

(d) Any owner or operator subject to the provisions of this part shall maintain a file of all measurements, including monitoring and performance testing measurements, and all other reports and records required by all applicable subparts. Any such instruments, reports and records shall be retained for at least 2 years following the date of such measurements, reports, and records.

§60.8 Performance tests.

(a) Within 60 days after achieving the maximum production rate at which the affected facility will be operated, but not later than 180 days after initial start-up of such facility and at such other times as may be required by the Administrator under section 114 of the Act, the owner or operator of such facility shall conduct performance test(s) and furnish the Administrator with a written report of the results of such performance test(s).

(b) Performance tests shall be conducted and data reduced in accordance with the test methods and procedures contained in each applicable subpart unless the Administrator (1) specifies or approves, in specific cases, the use of a reference method with minor changes in methodology, (2) approves the use of an equivalent method, (3) approves the use of an alternative method the results of which he has determined to be adequate for indicating whether a specific source is in compliance, or (4) waives the requirement for performance tests because the owner or operator of a source has demonstrated by other means to the Administrator's satisfaction that the affected facility is in compliance with the standard. Nothing in this paragraph shall be construed to abrogate the Administrator's authority to require testing under section 114 of the Act.

(c) Performance tests shall be conducted under such conditions as the Administrator shall specify to the plant operator based on representative performance of the affected facility. The owner or operator shall make available to the Administrator such records as may be necessary to determine the conditions of the performance tests. Operations during periods of start-up, shutdown, and malfunction shall not constitute representative conditions of performance tests unless otherwise specified in the applicable standard.

(d) The owner and operator of an affected facility shall provide the Administrator 30 days prior notice of the performance test to afford the Administrator the opportunity to have an observer present.

(e) The owner or operator of an affected facility shall provide or cause to be provided, performance testing facilities as follows:

(1) Sampling ports adequate for test methods applicable to such facility.

(2) Safe sampling platform(s).

(3) Safe access to sampling platform(s).

(4) Utilities for sampling and testing equipment.

(f) Each performance test shall consist of three separate runs using the applicable test method. Each run shall be conducted for the time and under the conditions specified in the applicable standard. For the purpose of determining compliance with an applicable standard, the arithmetic means of results of the three runs shall apply. In the event that a sample is accidentally lost or conditions occur in which one of the three runs must be discontinued because of forced shutdown, failure of an irreplaceable portion of the sample train, extreme meteorological conditions, or other circumstances, beyond the owner or operator's control, compliance may, upon the Administrator's approval, be determined using the arithmetic mean of the results of the two other runs.

§60.9 Availability of information.

(a) Emission data provided to, or otherwise obtained by, the Administrator in accordance with the provisions of this part shall be available to the public.

(b) Except as provided in paragraph (a) of this section, any records, reports, or information provided to, or otherwise obtained by, the Administrator in accordance with the provisions of this part shall be available to the public, except that (1) upon a showing satisfactorily to the Administrator by any person that such records, reports, or information, or particular part thereof (other than emission data), if made public, would divulge methods or processes entitled to protection as trade secrets of such person, the Administrator shall consider such records, reports, or information, or particular part thereof, confidential in accordance with the purposes of section 1905 of title 18 of the United States Code, except that such records, reports, or information, or particular part thereof, may be disclosed to other officers, employees, or authorized representatives of the United States concerned with carrying out the provisions of the Act or when relevant in any proceeding under the Act; and (2) information received by the Administrator solely for the purposes of §60.5 and §60.8 shall not be disclosed if it is so identified by the owner or operator as being a trade secret or commercial or financial information which such owner or operator considers confidential.

§60.10 State authority.

The provisions of this part shall not be construed in any manner to preclude any State or political subdivision thereof from:

(a) Adopting and enforcing any emission standard or limitation applicable to an affected facility, provided that such emission standard or limitation is not less stringent than the standard applicable to such facility.

(b) Requiring the owner or operator of an affected facility to obtain permits, licenses, or approvals prior to initiating construction, modification, or operation of such facility.

§60.11 Compliance with standards and maintenance requirements.

(a) Compliance with standards in this part, other than opacity standards, shall be determined only by performance tests established by §60.8.

(b) Compliance with opacity standards in this part shall be determined by conducting observations in accordance with Reference Method 9 in Appendix A of this part. Opacity readings of portions of plumes which contain condensed, uncombined water vapor shall not be used for purposes of determining compliance with opacity standards. The results of continuous monitoring by transmissometer which indicate that the opacity at the time visual observations were made was not in excess of the standard are probative but not conclusive evidence of the actual opacity of an emission, provided that the source shall meet the burden of proving that the instrument used meets (at the time of the alleged violation) Performance Specification I in Appendix B of this part, has been properly maintained and (at the time of the alleged violation) calibrated, and that the resulting data have not been tampered with in any way.

(c) The opacity standards set forth in this part shall apply at all times except during periods of start-up, shutdown, or malfunction, and as otherwise provided in the applicable standard.

(d) At all times, including periods of start-up, shutdown, and malfunction, owners and operators shall, to the extent practicable, maintain and operate any affected facility including associated air pollution control equipment in a manner consistent with good air pollution control practice for minimizing emissions. Determination of whether acceptable operating and maintenance procedures are being used will be based on information available to the Administrator which may include, but is not limited to, monitoring results, opacity observations, review of operating and maintenance procedures, and inspection of the source.

(e)(1) An owner or operator of an affected facility may request the Administrator to determine opacity of emissions from the affected facility during the initial performance tests required by §60.8.

(2) Upon receipt from such owner or operator of the written report of the results of the performance test required by §60.8, the Administrator will make a finding concerning compliance with opacity and other applicable standards. If the Administrator finds that an affected facility is in compliance with all applicable standards for which performance tests are conducted in accordance with §60.8 of this part but during the time such performance tests are being conducted fails to meet any applicable opacity standard, he shall notify the owner or operator and advise him that he may petition the Administrator within 10 days of receipt of notification to make appropriate adjustment to the opacity standard for the affected facility.

(3) The Administrator will grant such a petition upon a demonstration by the owner or operator that the affected facility and associated air pollution control equipment was operated and maintained in a manner to minimize the opacity

of emissions during the performance tests; that the performance tests were performed under the conditions established by the Administrator; and that the affected facility and associated air pollution control equipment were incapable of being adjusted or operated to meet the applicable opacity standard.

(4) The Administrator will establish an opacity standard for the affected facility meeting the above requirements at a level at which the source will be able, as indicated by the performance and opacity tests, to meet the opacity standard at all times during which the source is meeting the mass or concentration emission standard. The Administrator will promulgate the new opacity standard in the Federal Register.

§60.12 Circumvention.

No owner or operator subject to the provisions of this part shall build, erect, install, or use any article, machine, equipment or process, the use of which conceals an emission which would otherwise constitute a violation of an applicable standard. Such concealment includes, but is not limited to, the use of gaseous diluents to achieve compliance with an opacity standard or with a standard which is based on the concentration of a pollutant in the gases discharged to the atmosphere.

Subpart E - Standards of Performance for Incinerators

§60.50 Applicability and designation of affected facility.

The provisions of this subpart are applicable to each incinerator of more than 45 metric tons per day charging rate (50 tons/day), which is the affected facility.

§60.51 Definitions.

As used in this subpart, all terms not defined herein shall have the meaning given them in the Act and in Subpart A of this part.

(a) "Incinerator" means any furnace used in the process of burning solid waste for the purpose of reducing the volume of the waste by removing combustible matter.

(b) "Solid waste" means refuse, more than 50 percent of which is municipal type waste consisting of a mixture of paper, wood, yard wastes, food wastes, plastics, leather, rubber, and other combustibles, and noncombustible materials such as glass and rock.

(c) "Day" means 24 hours.

(d) "Particulate matter" means any finely divided liquid or solid material, other than uncombined water, as measured by Method 5.

§60.52 Standard for particulate matter.

On and after the date on which the performance test required to be conducted by §60.8 is completed, no owner or operator subject to the provisions of this part shall discharge or cause the discharge into the atmosphere of particulate matter which is in excess of 0.18 g/dscm (0.08 gr/dscf) corrected to 12 percent CO_2.

§60.53 Monitoring of operations.

The owner or operator of any incinerator subject to the provisions of this part shall maintain a file of daily burning rates and hours of operation.

§60.54 Test methods and procedures.

(a) The reference methods in Appendix A to this part, except as provided for in §60.8(b), shall be used to determine compliance with the standard prescribed in §60.52 as follows:

(1) Method 5 for the concentration of particulate matter and the associated moisture content;

(2) Method 1 for sample and velocity traverses;

(3) Method 2 for velocity and volumetric flow rate; and

(4) Method 3 for gas analysis and calculation of excess air, using the integrated sample technique.

(b) For Method 5, the sampling time for each run shall be at least 60 minutes and the minimum sample volume shall be 0.85 dscm (30.0 dscf) except that smaller sampling times or sample volumes, when necessitated by process variables or other factors, may be approved by the Administrator.

(c) If a wet scrubber is used, the gas analysis sample shall reflect flue gas conditions after the scrubber, allowing for carbon dioxide absorption by sampling the gas on the scrubber inlet and outlet sides according to either the procedure under paragraphs (c)(1) through (c)(5) of this section or the procedure under paragraphs (c)(1), (c)(2) and (c)(6) of this section as follows:

(1) The outlet sampling site shall be the same as for the particulate matter measurement. The inlet site shall be selected according to Method 1, or as specified by the Administrator.

(2) Randomly select 9 sampling points within the cross-section at both the inlet and outlet sampling sites. Use the first set of three for the first run, the second set for the second run, and the third set for the third run.

(3) Simultaneously with each particulate matter run, extract and analyze for CO_2 an integrated gas sample according to Method 3, traversing the three sample points and sampling at each point for equal increments of time. Conduct the runs at both inlet and outlet sampling sites.

(4) Measure the volumetric flow rate at the inlet

during each particulate matter run according to Method 2, using the full number of traverse points. For the inlet make two full velocity traverses approximately one hour apart during each run and average the results. The outlet volumetric flow rate may be determined from the particulate matter run (Method 5).

(5) Calculate the adjusted CO_2 percentage using the following equation:

$$(\%\ CO_2)adj = (\%\ CO_2)di(Qdi/Qdo)$$

where:

$(\%\ CO_2)adj$ is the adjusted CO_2 percentage which removes the effect of CO_2 absorption and dilution air,

$(\%\ CO_2)di$ is the percentage of CO_2 measured before the scrubber, dry basis,

Qdi is the volumetric flow rate before the scrubber, average of two runs, dscf/min (using Method 2), and

Qdo is the volumetric flow rate after the scrubber, dscf/ min (using Methods 2 and 5).

(6) Alternatively, the following procedures may be substituted for the procedures under paragraphs (c)(3), (4), and (5) of this section:

(i) Simultaneously with each particulate matter run, extract and analyze for CO_2, O_2, and N_2 an integrated gas sample according to Method 3, traversing the three sample points and sampling for equal increments of time at each point. Conduct the runs at both the inlet and outlet sampling sites.

(ii) After completing the analysis of the gas sample, calculate the percentage of excess air (% EA) for both the inlet and outlet sampling sites using equation 3-1 in Appendix A to this part.

(iii) Calculate the adjusted CO_2 percentage using the following equation:

$$(\%\ CO_2)adj = (\%\ CO_2)di \left[\frac{100+\ (\%\ EA)i}{100+\ (\%\ EA)o}\right]$$

where:

$(\%\ CO_2)adj$ is the adjusted outlet CO_2 percentage,

$(\%\ CO_2)di$ is the percentage of CO_2 measured before the scrubber, dry basis,

(% EA)i is the percentage of excess air at the inlet, and

(% EA)o is the percentage of excess air at the outlet.

(d) Particulate matter emissions, expressed in g/dscm, shall be corrected to 12 percent CO_2 by using the following formula:

$$c_{12} = \frac{12c}{\%\ CO_2}$$

where:

c_{12} is the concentration of particulate matter corrected to 12 percent CO_2,

c is the concentration of particulate matter as measured by Method 5, and

% CO_2 is the percentage of CO_2 as measured by Method 3, or when applicable, the adjusted outlet CO_2 percentage as determined by paragraph (c) of this section.

APPENDIX - TEST METHODS

Method 1 - Sample and Velocity Traverses For Stationary Sources

1. Principle and Applicability

1.1 Principle. A sampling site and the number of traverse points are selected to air in the extraction of a representative sample.

1.2 Applicability. This method should be applied only when specified by the test procedures for determining compliance with the New Source Performance Standards. Unless otherwise specified, this method is not intended to apply to gas streams other than those emitted directly to the atmosphere without further processing.

2. Procedure

2.1 Selection of a sampling site and minimum number of traverse points.

2.1.1 Select a sampling site that is at least eight stack or duct diameters downstream and two diameters upstream from any flow disturbance such as a bend, expansion, contraction, or visible flame. For rectangular cross section, determine an equivalent diameter from the following equation:

$$\text{equivalent diameter} = 2\left(\frac{(\text{length})(\text{width})}{\text{length} + \text{width}}\right) \qquad \text{equation 1-1}$$

2.1.2 When the above sampling site criteria can be met, the minimum number of traverse points is twelve (12).

2.1.3 Some sampling situations render the above sampling site criteria impractical. When this is the case, choose a convenient sampling location and use Figure 1-1 to determine the minimum number of traverse points. Under no conditions should a sampling point be selected within 1 inch of the stack wall. To obtain the number of traverse points for stacks or ducts with a diameter less than 2 feet, multiply the number of points obtained from Figure 1-1 by 0.67.

2.1.4 To use Figure 1-1 first measure the distance from the chosen sampling location to the nearest upstream and downstream disturbances. Determine the corresponding number of traverse points for each distance from Figure 1-1.

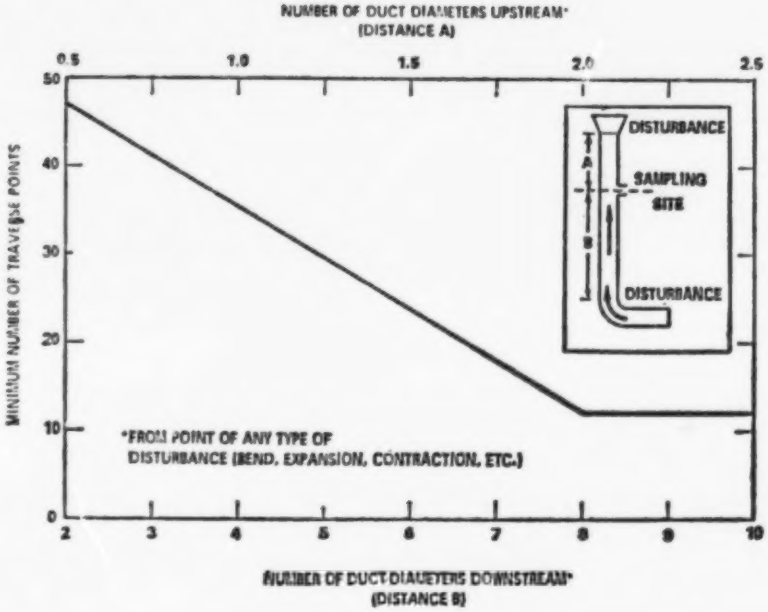

Figure 1-1. Minimum number of traverse points.

Select the higher of the two numbers of traverse points, or a greater value, such that for circular stacks the number is a multiple of 4, and for rectangular stacks the number follows the criteria of section 2.2.2.

2.2 Cross-sectional layout and location of traverse points.

2.2.1 For circular stacks locate the traverse points on at least two diameters according to Figure 1-2 and Table 1-1. The traverse axes shall divide the stack cross section into equal parts.

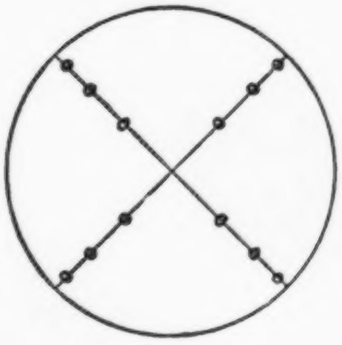

Figure 1-2. Cross section of circular stack divided into 12 equal areas, showing location of traverse points at centroid of each area.

Table 1-1. Location of traverse points in circular stacks
(Percent of stack diameter from inside wall to traverse point)

Traverse point number on a diameter	Number of traverse points on a diameter											
	2	4	6	8	10	12	14	16	18	20	22	24
1	14.6	6.7	4.4	3.3	2.5	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	85.4	25.0	14.7	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3		75.0	29.5	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4		93.3	70.5	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5			85.3	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6			95.6	80.6	65.8	35.5	26.9	22.0	18.8	16.5	14.6	13.2
7				89.5	77.4	64.5	36.6	28.3	23.6	20.4	18.0	16.1
8				96.7	85.4	65.0	63.4	37.5	29.6	25.0	21.8	19.4
9					91.8	82.3	73.1	62.5	38.2	30.6	26.1	23.0
10					97.5	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11						93.3	85.4	78.0	70.4	61.2	39.3	32.3
12						97.9	90.1	83.1	76.4	69.4	60.7	39.8
13							94.3	87.5	81.2	75.0	68.5	60.2
14							98.2	91.5	85.4	79.6	73.9	67.7
15								95.1	89.1	83.5	78.2	72.8
16								98.4	92.5	87.1	82.0	77.0
17									95.6	90.3	85.4	80.6
18									98.6	93.3	88.4	83.9
19										96.1	91.3	86.8
20										98.7	94.0	89.5
21											96.5	92.1
22											98.9	94.5
23												96.8
24												98.9

2.2.2 For rectangular stacks divide the cross section into as many equal rectangular areas as traverse points, such that the ratio of the length to the width of the elemental areas is between one and two. Locate the traverse points at the centroid of each equal area according to Figure 1-3.

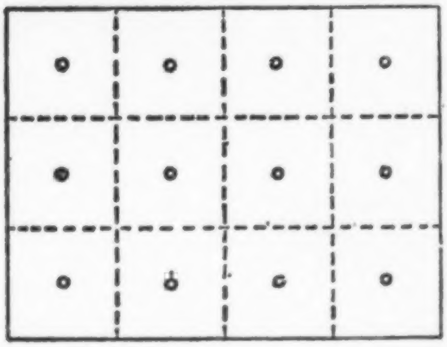

Figure 1-3. Cross section of rectangular stack divided into 12 equal areas, with traverse points at centroid of each area.

3. References

Determining Dust Concentration in a Gas Stream, ASME Performance Test Code #27, New York, N.Y., 1957.

Devorkin, Howard, et al., Air Pollution Source Testing Manual, Air Pollution Control District, Los Angeles, California, November 1963.

Methods for Determination of Velocity, Volume, Dust and Mist Content of Gases, Western Precipitation Division of Joy Manufacturing Co., Los Angeles, California, Bulletin WP-50, 1968.

Standard Method for Sampling Stacks for Particulate Matter, In: 1971 Book of ASTM Standards, Part 23, Philadelphia, Pennsylvania, 1971, ASTM Designation D-2928-71.

Method 2 - Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)

1. Principle and applicability

1.1 Principle. Stack gas velocity is determined from the gas density and from measurement of the velocity head using a Type S (Stauscheibe or reverse type) pitot tube.

1.2 Applicability. This method should be applied only when specified by the test procedures for determining compliance with the New Source Performance Standards.

2. Apparatus

2.1 Pitot tube - Type S (Figure 2-1), or equivalent, with a coefficient within ±5% over the working range.

2.2 Differential pressure gauge - Inclined manometer, or equivalent, to measure velocity head to within 10% of the minimum value.

2.3 Temperature gauge - Thermocouple or equivalent attached to the pitot tube to measure stack temperature to within 1.5% of the minimum absolute stack temperature.

2.4 Pressure gauge - Mercury-filled U-tube manometer, or equivalent, to measure stack pressure to within 0.1 in. Hg.

2.5 Barometer - To measure atmospheric pressure to within 0.1 in. Hg.

2.6 Gas analyzer - To analyze gas composition for determining molecular weight.

2.7 Pitot tube - Standard type, to calibrate Type S pitot tube.

3. Procedure

3.1 Set up the apparatus as shown in Figure 2-1. Make sure all connections are tight and leak free. Measure the velocity head and temperature at the traverse points specified by Method 1.

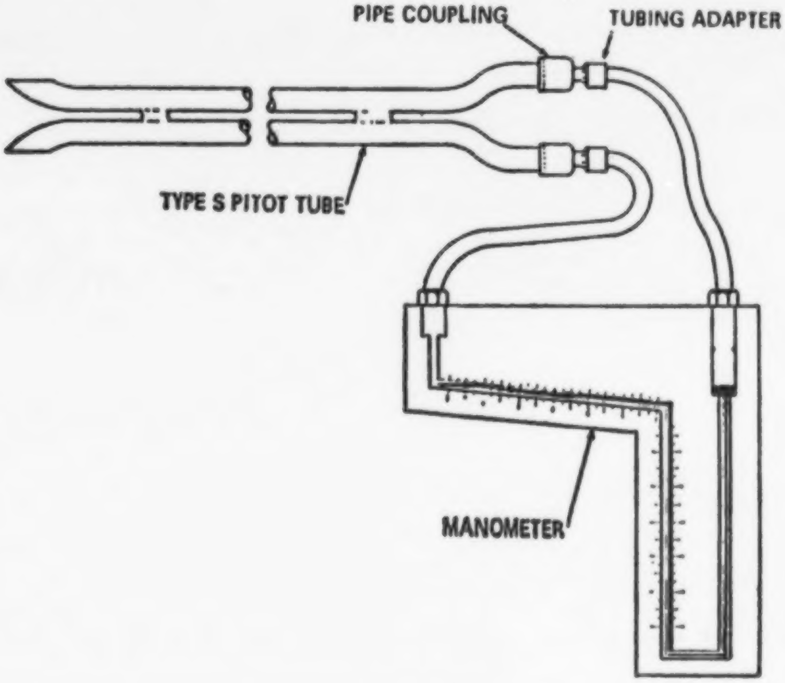

Figure 2-1. Pitot tube-manometer assembly.

3.2 Measure the static pressure in the stack.

3.3 Determine the stack gas molecular weight by gas analysis and appropriate calculations as indicated in Method 3.

4. Calibration

4.1 To calibrate the pitot tube, measure the velocity heat at some point in a flowing gas stream with both a Type S pitot tube and a standard type pitot tube with known coefficient. Calibration should be done in the laboratory and the velocity of the flowing gas stream should be varied over the normal working range. It is recommended that the calibration be repeated after use at each field site.

4.2 Calculate the pitot tube coefficient using equation 2-1.

$$C_{p_{test}} = C_{p_{std}} \sqrt{\frac{\Delta P_{std}}{\Delta P_{test}}} \qquad \text{equation 2-l}$$

where:

$C_{p_{test}}$ = Pitot tube coefficient of Type S pitot tube.

$C_{p_{std}}$ = Pitot tube coefficient of standard type pitot tube (if unknown, use 0.99)

Δp_{std} = Velocity head measured by standard type pitot tube.

Δp_{test} = Velocity head measured by Type S pitot tube.

4.3 Compare the coefficients of the Type S pitot tube determined first with one leg and then the other pointed downstream. Use the pitot tube only if the two coefficients differ by no more than 0.01.

5. Calculations

Use equation 2-2 to calculate the stack gas velocity.

$$(V_s)_{avg.} = K_p C_p (\sqrt{\Delta p})_{avg.} \sqrt{\frac{(T_s)_{avg.}}{P_s M_s}} \qquad \text{equation 2-2}$$

where:

$(V_s)_{avg.}$ = Stack gas velocity, feet per second (f.p.s.)

$K_p = 85.48 \frac{ft.}{sec.} \left(\frac{lb.}{lb.mole-°R}\right)^{1/2}$ when these units are used.

C_p = Pitot tube coefficient, dimensionless.

$(T_s)_{avg.}$ = Average absolute stack gas temperature, °R.

$(\sqrt{\Delta p})_{avg.}$ = Average velocity head of stack gas, inches H_2O (see Figure 2-2).

P_s = Absolute velocity head of stack gas (wet basis), lb/lb-mole.

M_s = Molecular weight of stack gas (wet basis), lb./lb.-mole $M_d(1-B_{wo})+18B_{wo}$

M_d = Dry molecular weight of stack gas (from Method 3).

B_{wo} = Proportion by volume of water vapor in the gas stream (from Method 4).

Figure 2-2 shows a sample recording sheet for velocity traverse data. Use the averages in the last two columns of Figure 2-2 to determine the average stack gas velocity from Equation 2-2.

PLANT ____________________

DATE ____________________

RUN NO. ____________________

STACK DIAMETER, in. ____________________

BAROMETRIC PRESSURE, in. Hg ____________________

STATIC PRESSURE IN STACK (P_g), in. Hg. __________

OPERATORS ____________________

SCHEMATIC OF STACK CROSS SECTION

Traverse point number	Velocity head, in. H_2O	$\sqrt{\Delta_p}$	Stack Temperature (T_s), °F
	AVERAGE:		

Figure 2-2. Velocity traverse data.

Use Equation 2-3 to calculate the stack gas volumetric flow rate.

$$Q_s = 3600\,(1 - B_{wo})V_sA \left(\frac{T_{std}}{(T_s)_{avg.}}\right)\left(\frac{P_s}{P_{std}}\right) \qquad \text{equation 2-3}$$

where:

Q_s = Volumetric flow rate, dry basis, standard conditions, $ft.^3/hr.$

A = Cross-sectional area of stack, ft^2

T_{std} = Absolute temperature at standard conditions, 530°R.

P_{std} = Absolute pressure at standard conditions, 29.92 inches Hg.

6. References

Mark, L. S., Mechanical Engineers' Handbook, McGraw-Hill Book Co., Inc., New York, N.Y., 1951.

Perry, J. H., Chemical Engineers' Handbook, McGraw-Hill Book Co., Inc., New York, N.Y., 1960.

Shigehara, R. T., W. F. Todd, and W. S. Smith, Significance of Errors in Stack Sampling Measurements. Paper presented at the Annual Meeting of the Air Pollution Control Association, St. Louis, Missouri, June 14-19, 1970.

Standard Method for Sampling Stacks for Particulate Matter, In: 1971 Book of ASTM Standards, Part 23, Philadelphia, Pennsylvania, 1971, ASTM Designation D-2928-71.

Vennard J. D., Elementary Fluid Mechanics, John Wiley & Sons, Inc., New York, N.Y., 1947.

Method 3 - Gas Anaylsis for Carbon Dioxide, Excess Air, and Dry Molecular Weight

1. Principle and applicability

1.1 Principle. An integrated or grab gas sample is extracted from a sampling point and analyzed for its components using an Orsat analyzer.

1.2 Applicability. This method should be applied only when specified by the test procedures for determining compliance with the New Source Performance Standards. The test procedure will indicate whether a grab sample or an integrated sample is to be used.

2. Apparatus

2.1 Grab sample (Figure 3-1).

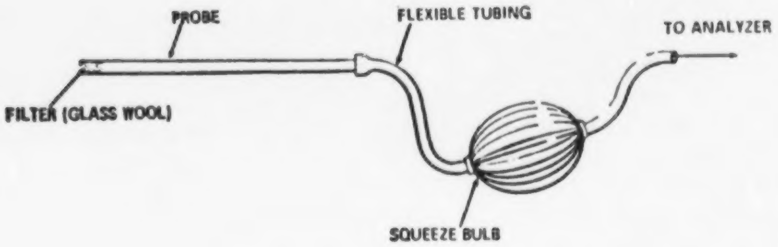
PROBE
FLEXIBLE TUBING
TO ANALYZER
FILTER (GLASS WOOL)
SQUEEZE BULB

Figure 3-1. Grab-sampling train.

2.1.1 Probe - Stainless steel or Pyrex[1] glass, equipped with a filter to remove particulate matter.

2.1.2 Pump - One-way squeeze bulb, or equivalent, to transport gas sample to analyzer.

2.2 Integrated sample (Figure 3-2).

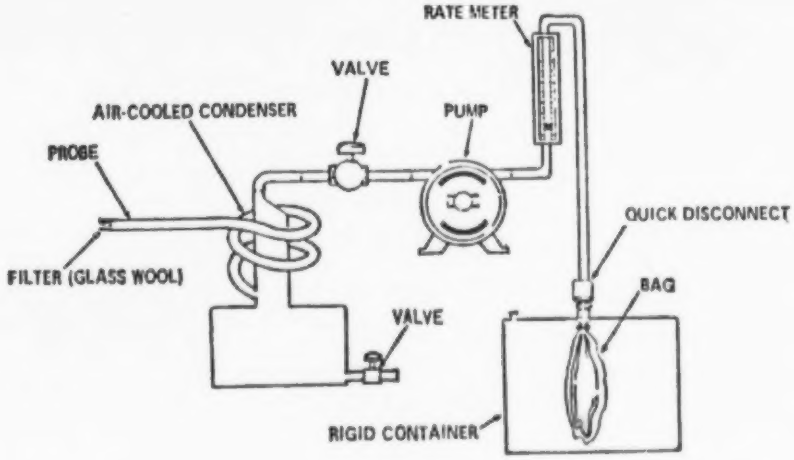
RATE METER
VALVE
AIR-COOLED CONDENSER
PUMP
PROBE
QUICK DISCONNECT
FILTER (GLASS WOOL)
BAG
VALVE
RIGID CONTAINER

Figure 3-2. Integrated gas - sampling train.

2.2.1 Probe - Stainless steel or Pyrex[1] glass, equipped with a filter to remove particulate matter.

2.2.2 Air-cooled condenser or equivalent - To remove any excess moisture.

2.2.3 Needle valve - To adjust flow rate.

2.2.4 Pump - Leak-free, diaphragm type, or equivalent, to pull gas.

2.2.5 Rate meter - To measure a flow range from 0 to 0.035 cfm.

---

[1] Trade name.

2.2.6 Flexible bag - Tedlar,[1] or equivalent, with a capacity of 2 to 3 cu. ft. Leak test the bag in the laboratory before using.

2.2.7 Pitot tube - Type S, or equivalent, attached to the probe so that the sampling flow rate can be regulated proportional to the stack gas velocity when velocity is varying with time or a sample traverse is conducted.

2.3 Analysis

2.3.1 Orsat analyzer, or equivalent.

3. Procedure

3.1 Grab sampling

3.1.1 Set up the equipment as shown in Figure 3-1, making sure all connections are leak-free. Place the probe in the stack at a sampling point and purge the sampling line.

3.1.2 Draw sample into the analyzer.

3.2 Integrated Sampling

3.2.1 Evacuate the flexible bag. Set up the equipment as shown in Figure 3-2 with the bag disconnected. Place the probe in the stack and purge the sampling line. Connect the bag, making sure that all connections are tight and that there are no leaks.

3.2.2 Sample at a rate proportional to the stack velocity.

3.3 Analysis

3.3.1 Determine the CO_2, O_2, and CO concentrations as soon as possible. Make as many passes as are necessary to give constant readings. If more than ten passes are necessary, replace the absorbing solution.

3.3.2 For grab sampling, repeat the sampling and analysis until three consecutive samples vary no more than 0.5 percent by volume for each component being analyzed.

3.3.3 For integrated sampling, repeat the analyses of the sample until three consecutive analyses vary no more than 0.2 percent by volume for each component being analyzed.

4. Calculations

4.1 Carbon dioxide. Average the three consecutive runs and report the results to the nearest 0.1% CO_2.

4.2 Excess air. Use Equation 3-1 to calculate excess air, and average the runs. Report the result to the nearest 0.1% excess air.

$$\%EA = \frac{(\%O_2) - 0.5(\%CO)}{0.264(\%N_2) - (\%O_2) + 0.5(\%CO)} \times 100 \qquad \text{equation 3-I}$$

---

[1] Trade name.

where:

$\%EA$ = Percent excess air.

$\%O_2$ = Percent oxygen by volume, dry basis.

$\%N_2$ = Percent nitrogen by volume, dry basis.

$\%CO$ = Percent carbon monoxide by volume, dry basis.

0.264 = Ratio of oxygen to nitrogen in air by volume.

4.3 Dry molecular weight. Use Equation 3-2 to calculate dry molecular weight and average the runs. Report the result to the nearest tenth.

$$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2 + \%\,CO) \qquad \text{equation 3-2}$$

where:

M_d = Dry molecular weight, lb./lb-mole.

$\%CO_2$ = Percent carbon dioxide by volume, dry basis.

$\%O_2$ = Percent oxygen by volume, dry basis.

$\%N_2$ = Percent nitrogen by volume, dry basis.

0.44 = Molecular weight of carbon dioxide divided by 100.

0.32 = Molecular weight of oxygen divided by 100.

0.28 = Molecular weight of nitrogen and CO divided by 100.

5. References

Altshuller, A. P., et al., Storage of Gases and Vapors in Plastic Bags, Int. J. Air & Water Pollution, 6:75-81, 1963.

Conner, William D., and J. S. Nader, Air Sampling with Plastic Bags, Journal of the American Industrial Hygiene Association, 25:291-297, May-June 1964.

Devorkin, Howard, et al., Air Pollution Source Testing Manual, Air Pollution Control District, Los Angeles, California, November 1963.

Method 4 - Determination of Moisture in Stack Gases

1. Principle and applicability

1.1 Principle. Moisture is removed from the gas stream, condensed, and determined volumetrically.

1.2 Applicability. This method is applicable for the determination of moisture in stack gas only when specified by test procedures for determining compliance with New Source Performance Standards. This method does not apply when liquid droplets are present in the gas stream[1] and the moisture is subsequently used in the determination of stack gas molecular weight.

Other methods such as drying tubes, wet bulb-dry bulb techniques, and volumetric condensation techniques may be used.

2. Apparatus

2.1 Probe - Stainless steel or Pyrex[2] glass sufficiently heated to prevent condensation and equipped with a filter to remove particulate matter.

2.2 Impingers - Two midget impingers, each with 30 ml. capacity, or equivalent.

2.3 Ice bath container - To condense moisture in impingers.

2.4 Silica gel tube (optional) - To protect pump and dry gas meter.

2.5 Needle valve - To regulate gas flow rate.

2.6 Pump - Leak-free, diaphragm type, or equivalent, to pull gas through train.

2.7 Dry gas meter - To measure to within 1% of the total sample volume.

2.8 Rotameter - To measure a flow range from 0 to 0.1 c.f.m.

2.9 Graduated cylinder - 25 ml.

2.10 Barometer - Sufficient to read to within 0.1 inch Hg.

2.11 Pitot tube - Type S, or equivalent, attached to probe so that the sampling flow rate can be regulated proportional to the stack gas velocity when velocity is varying with time or a sample traverse is conducted.

---

[1] If liquid droplets are present in the gas stream, assume the stream to be saturated, determine the average stack gas temperature by traversing according to Method 1, and use a psychrometric chart to obtain an approximation of the moisture percentage.

[2] Trade name.

3. Procedure

3.1 Place exactly 5 ml. distilled water in each impinger. Assemble the apparatus without the probe as shown in Figure 4-1. Leak check by plugging the inlet to the first impinger and drawing a vacuum. Insure that flow through the dry gas meter is less than 1% of the sampling rate.

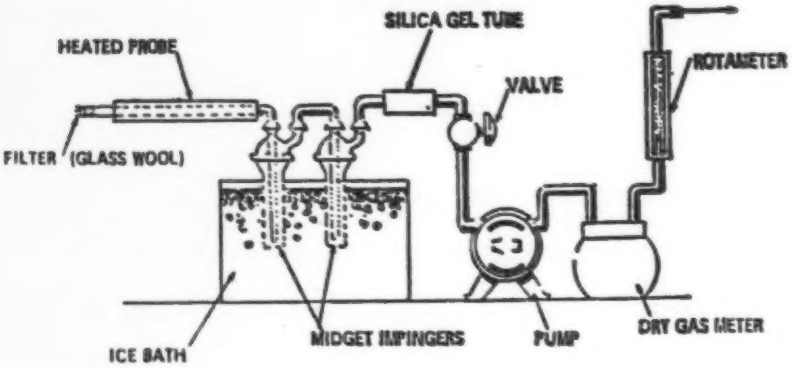
SILICA GEL TUBE
HEATED PROBE
ROTAMETER
VALVE
FILTER (GLASS WOOL)
ICE BATH
MIDGET IMPINGERS
PUMP
DRY GAS METER

Figure 4-1. Moisture-sampling train.

3.2 Connect the probe and sample at a constant rate of 0.075 c.f.m. or at a rate proportional to the stack gas velocity. Continue sampling until the dry gas meter registers 1 cubic foot or until visible liquid droplets are carried over from the first impinger to the second. Record temperature, pressure, and dry gas meter readings as required by Figure 4-2.

LOCATION________________________ COMMENTS
TEST________________________
DATE________________________
OPERATOR________________________

BAROMETRIC PRESSURE________________

CLOCK TIME	GAS VOLUME THROUGH METER, (Vm), ft^3	ROTAMETER SETTING ft^3/min	METER TEMPERATURE, °F

Figure 4-2. Field moisture determination.

3.3 After collecting the sample, measure the volume increase to the nearest 0.5 ml.

4. Calculations

4.1 Volume of water vapor collected.

$$V_{wc} = \frac{(V_f - V_i) p_{H_2O} R T_{std}}{P_{std} M_{H_2O}} = 0.0474 \frac{ft^3}{ml.} (V_f - V_i) \qquad \text{equation 4-1}$$

where:

V_{wc} = Volume of water vapor collected (standard conditions), cu.ft.

V_f = Final volume of impinger contents, ml.

V_i = Initial volume of impinger contents, ml.

R = Ideal gas constant, 21.83 inches Hg - cu.ft./lb.mole-°R.

P_{H_2O} = Density of water, 1 g./ml.

T_{std} = Absolute temperature at standard conditions, 530°R.

P_{std} = Absolute pressure at standard conditions, 29.92 inches Hg.

M_{H_2O} = Molecular weight of water, 18 lb./lb.-mole.

4.2 Gas volume.

$$V_{mc} = V_m \left(\frac{P_m}{P_{std}}\right) \left(\frac{T_{std}}{T_m}\right) = 17.71 \frac{°R}{in.\ Hg} \left(\frac{V_m P_m}{T_m}\right) \qquad \text{equation 4-2}$$

where:

V_{mc} = Dry gas volume through meter at standard conditions, cu.ft.

V_m = Dry gas volume measured by meter, cu.ft.

P_m = Barometric pressure at the dry gas meter, inches Hg.

P_{std} = Pressure at standard conditions, 29.92 inches Hg.

T_{std} = Absolute temperature at standard conditions, 530°R.

T_m = Absolute temperature at meter (°F+460), °R.

4.3 Moisture content.

$$B_{wo} = \frac{V_{wc}}{V_{wc} + V_{mc}} + B_{wm} = \frac{V_{wc}}{V_{wc} + V_{mc}} + (0.025) \qquad \text{equation 4-3}$$

where:

B_{wo} = Proportion by volume of water vapor in the gas stream, dimensionless.

V_{wc} = Volume of water vapor collected (standard conditions), cu.ft.

V_{mc} = Dry gas volume through meter (standard conditions), cu.ft.

B_{wm} = Approximate volumetric proportion of water vapor in the gas stream leaving the impingers, 0.025.

5. References

Air Pollution Engineering Manual, Danielson, J. A. (ed.), U.S. DHEW, PHS, National Center for Air Pollution Control, Cincinnati, Ohio, PHS Publication No. 999-AP-40, 1967.

Devorkin, Howard, et al., Air Pollution Source Testing Manual, Air Pollution Control District, Los Angeles, California, November 1963.

Methods for Determination of Velocity, Volume, Dust and Mist Content of Gases, Western Precipitation Division of Joy Manufacturing Co., Los Angeles, California, Bulletin WP-50, 1968.

Method 5 - Determination of Particulate Emissions From Stationary Sources

1. Principle and applicability

1.1 Principle. Particulate matter is withdrawn isokinetically from the source and its weight is determined gravimetrically after removal of uncombined water.

1.2 Applicability. This method is applicable for the determination of particulate emissions from stationary sources only when specified by the test procedures for determining compliance with New Source Performance Standards.

2. Apparatus

2.1 Sampling train. The design specifications of the particulate sampling train used by EPA (Figure 5-1) are described in APTD-0581. Commercial models of this train are available.

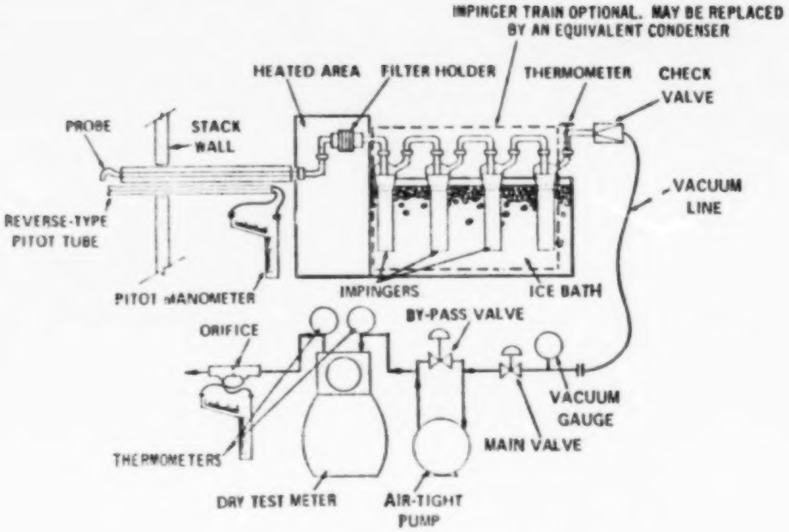
IMPINGER TRAIN OPTIONAL. MAY BE REPLACED BY AN EQUIVALENT CONDENSER
HEATED AREA
FILTER HOLDER
THERMOMETER
CHECK VALVE
PROBE
STACK WALL
VACUUM LINE
REVERSE-TYPE PITOT TUBE
PITOT MANOMETER
IMPINGERS
ICE BATH
BY-PASS VALVE
ORIFICE
VACUUM GAUGE
MAIN VALVE
THERMOMETERS
DRY TEST METER
AIR-TIGHT PUMP

Figure 5-1. Particulate-sampling train.

2.1.1 Nozzle - Stainless steel (316) with sharp, tapered leading edge.

2.1.2 Probe - Pyrex[1] glass with a heating system capable of maintaining a minimum gas temperature of 250°F at the exit end during sampling to prevent condensation from occurring. When length limitations (greater than about 8 ft.) are encountered at temperatures less than 600°F, Incoloy 825[1], or equivalent, may be used. Probes for sampling gas streams at temperatures in excess of 600°F must have been approved by the Administrator.

2.1.3 Pitot tube - Type S, or equivalent, attached to probe to monitor stack gas velocity.

2.1.4 Filter holder - Pyrex[1] glass with heating system capable of maintaining minimum temperature of 225°F.

2.1.5 Impingers/Condenser - Four impingers connected in series with glass ball joint fittings. The first, third, and fourth impingers are of the Greenburg-Smith design, modified by replacing the tip with a 1/2-inch ID glass tube extending to one-half inch from the bottom of the flask. The second impinger is of the Greenburg-Smith design with the standard tip. A condenser may be used in place of the impingers provided that the moisture content of the stack gas can still be determined.

2.1.6 Metering system - Vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 5°F, dry gas meter with 2% accuracy, and related equipment, or equivalent, as required to maintain an isokinetic sampling rate and to determine sample volume.

2.1.7 Barometer - To measure atmospheric pressure to ±0.1 inches Hg.

---

[1] Trade name.

2.2 Sample recovery.
2.2.1 Probe brush - At least as long as probe.
2.2.2 Glass wash bottles - Two.
2.2.3 Glass sample storage containers.
2.2.4 Graduated cylinder - 250 ml.
2.3 Analysis.
2.3.1 Glass weighing dishes.
2.3.2 Desiccator.
2.3.3 Analytical balance - To measure to ±0.1 mg.

3. Reagents

3.1 Sampling

3.1.1 Filters - Glass fiber, MSA 1106 BH[1], or equivalent, numbered for identification and preweighed.

3.1.2 Silica gel - Indicating type, 6-16 mesh, dried at 175°C (350°F) for 2 hours.

3.1.3 Water.
3.1.4 Crushed ice.
3.2 Sample recovery.
3.2.1 Acetone - Reagent grade.
3.3 Analysis
3.3.1 Water.
3.3.2 Desiccant - Drierite,[1] indicating.

4. Procedure

4.1 Sampling

4.1.1 After selecting the sampling site and the minimum number of sampling points, determine the stack pressure, temperature, moisture, and range of velocity head.

4.1.2 Preparation of collection train. Weigh to the nearest gram approximately 200 g. of silica gel. Label a filter of proper diameter, desiccate[2] for at least 24 hours and weigh to the nearest 0.5 mg. in a room where the relative humidity is less than 50%. Place 100 ml. of water in each of the first two impingers, leave the third impinger empty, and place approximately 200 g. of preweighed silica gel in the fourth impinger. Set up the train without the probe as in Figure 5-1. Leak check the sampling train at the sampling site by plugging up the inlet to the filter holder and pulling a 15 in. Hg vacuum. A leakage rate not in excess of 0.02 c.f.m. at a vacuum of 15 in. Hg is acceptable. Attach the probe and adjust the heater to provide a gas temperature of about 250°F at the probe outlet. Turn on the filter heating system. Place crushed ice around the impingers. Add more ice during the run to keep the temperature of the gases leaving the last impinger as low as possible and preferably at 70°F or less. Temperatures above 70°F may result in damage to the dry gas meter from either moisture condensation or excessive heat.

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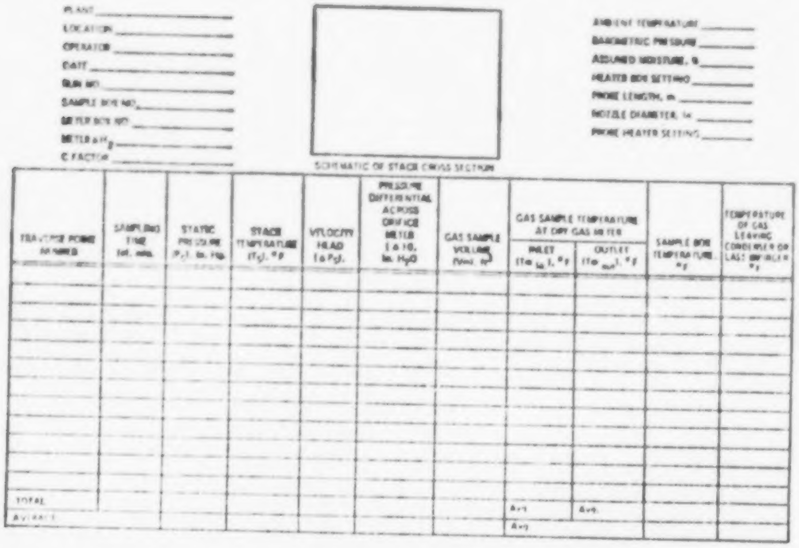
[1] Trade name.

[2] Dry using Drierite[1] at 70°F ±10°F.

4.1.3 Particulate train operation. For each run, record the data required on the example sheet shown in Figure 5-2. Take readings at each sampling point, at least every 5 minutes, and when significant changes in stack conditions necessitate additional adjustments in flow rate. To begin sampling, position the nozzle at the first traverse point with the tip pointing directly into the gas stream. Immediately start the pump and adjust the flow to isokinetic conditions. Sample for at least 5 minutes at each traverse point; sampling time must be the same for each point. Maintain isokinetic sampling throughout the sampling period. Nomographs are available which aid in the rapid adjustment of the sampling rate without other computations. APTD-0576 details the procedure for using these nomographs. Turn off the pump at the conclusion of each run and record the final readings. Remove the probe and nozzle from the stack and handle in accordance with the sampling recovery process described in section 4.2.



PLANT ______
LOCATION ______
OPERATOR ______
DATE ______
RUN NO. ______
SAMPLE BOX NO. ______
METER BOX NO. ______
METER ΔH@ ______
C FACTOR ______

SCHEMATIC OF STACK CROSS SECTION

AMBIENT TEMPERATURE ______
BAROMETRIC PRESSURE ______
ASSUMED MOISTURE, % ______
HEATER BOX SETTING ______
PROBE LENGTH, m ______
NOZZLE DIAMETER, in ______
PROBE HEATER SETTING ______

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (P_s), in. Hg	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH), in. H_2O	GAS SAMPLE VOLUME (V_m), ft^3	GAS SAMPLE TEMPERATURE AT DRY GAS METER		SAMPLE BOX TEMPERATURE, °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER, °F
							INLET ($T_{m_{in}}$), °F	OUTLET ($T_{m_{out}}$), °F		
TOTAL							Avg.	Avg.		
AVERAGE							Avg.			

Figure 5-2. Particulate field data.

4.2 Sample recovery. Exercise care in moving the collection train from the test site to the sample recovery area to minimize the loss of collected sample or the gain of extraneous particulate matter. Set aside a portion of the acetone used in the sample recovery as a blank for analysis. Measure the volume of water from the first three impingers, then discard. Place the samples in containers as follows:

Container No. 1. Remove the filter from its holder, place in this container, and seal.

Container No. 2. Place loose particulate matter and acetone washings from all sample-exposed surfaces prior to the filter in this container and seal. Use a razor blade, brush, or rubber policeman to lose adhering particles.

Container No. 3. Transfer the silica gel from the fourth impinger to the original container and seal. Use a rubber policeman as an aid in removing silica gel from the impinger.

4.3 Analysis. Record the data required on the example sheet shown in Figure 5-3. Handle each sample container as follows:

PLANT________________

DATE ________________

RUN NO.______________

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED, mg		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
1			
2			
TOTAL	☒	☒	

	VOLUME OF LIQUID WATER COLLECTED	
	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g
FINAL		
INITIAL		
LIQUID COLLECTED		
TOTAL VOLUME COLLECTED		g* ml

CONVERT WEIGHT OF WATER TO VOLUME BY DIVIDING TOTAL WEIGHT INCREASE BY DENSITY OF WATER. (1 g ml):

$$\frac{\text{INCREASE, g}}{(1\ \text{g/ml})} = \text{VOLUME WATER, ml}$$

Figure 5-3. Analytical data.

Container No. 1. Transfer the filter and any loose particulate matter from the sample container to a tared glass weighed dish, desiccate, and dry to a constant weight. Report results to the nearest 0.5 mg.

Container No. 2. Transfer the acetone washings to a tared beaker and evaporate to dryness at ambient temperature and pressure. Desiccate and dry to a constant weight. Report results to the nearest 0.5 mg.

Container No. 3. Weigh the spent silica gel and report to the nearest gram.

5. Calibration

Use methods and equipment which have been approved by the Administrator to calibrate the orifice meter, pitot tube, dry gas meter, and probe heater. Recalibrate after each test series.

6. Calculations

6.1 Average dry gas meter temperature and average orifice pressure drop. See data sheet (Figure 5-2).

6.2 Dry gas volume. Correct the sample volume measured by the dry gas meter to standard conditions (70°F, 29.92 inches Hg) by using Equation 5-1.

$$V_{m_{std}} = V_m \left(\frac{T_{std}}{T_m}\right)\left(\frac{P_{bar} + \frac{\Delta H}{13.6}}{P_{std}}\right) = \left(17.71 \ \frac{°R}{in.Hg}\right) V_m \left(\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right) \qquad \text{equation 5-1}$$

where:

$V_{m_{std}}$ = Volume of gas sample through the dry gas meter (standard conditions), cu. ft.

V_m = Volume of gas sample through the dry gas meter (meter conditions), cu. ft.

T_{std} = Absolute temperature at standard conditions, 530°R.

T_m = Average dry gas meter temperature, °R.

P_{bar} = Barometric pressure at the orifice meter, inches Hg.

ΔH = Average pressure drop across the orifice meter, inches H_2O.

13.6 = Specific gravity of mercury.

P_{std} = Absolute pressure at standard conditions, 29.92 inches Hg.

6.3 Volume of water vapor.

$$V_{w_{std}} = V_{1_c} \left(\frac{\rho_{H_2O}}{M_{H_2O}}\right) \left(\frac{RT_{std}}{P_{std}}\right) = \left(0.0474 \frac{\text{cu. ft.}}{\text{ml.}}\right) V_{1_c} \qquad \text{equation 5-2}$$

where:

$V_{w_{std}}$ = Volume of water vapor in the gas sample (standard conditions), cu. ft.

V_{1_c} = Total volume of liquid collected in impingers and silica gel (see Figure 5-3), ml.

ρ_{H_2O} = Density of water, 1 g./ml.

M_{H_2O} = Molecular weight of water, 18 lb./lb.-mole.

R = Ideal gas constant, 21.83 inches Hg-cu. ft./lb.-mole-°R.

T_{std} = Absolute temperature at standard conditions, 530°R.

P_{std} = Absolute pressure at standard conditions, 29.92 inches Hg.

6.4 Moisture content.

$$B_{wo} = \frac{V_{w_{std}}}{V_{m_{std}} + V_{w_{std}}} \qquad \text{equation 5-3}$$

where:

B_{wo} = Proportion by volume of water vapor in the gas stream, dimensionless.

$V_{w_{std}}$ = Volume of water in the gas sample (standard conditions), cu. ft.

$V_{m_{std}}$ = Volume of gas sample through the dry gas meter (standard conditions), cu. ft.

6.5 Total particulate weight. Determine the total particulate catch from the sum of the weights on the analysis data sheet (Figure 5-3).

6.6 Concentration.

6.6.1 Concentration in gr./s.c.f.

$$c'_s = \left(0.0154 \frac{\text{gr.}}{\text{mg.}}\right) \left(\frac{M_n}{V_{m_{std}}}\right) \qquad \text{equation 5-4}$$

where:

c'_s = Concentration of particulate matter in stack gas, gr./s.c.f., dry basis.

M_n = Total amount of particulate matter collected, mg.

$V_{m_{std}}$ = Volume of gas sample through dry gas meter (standard conditions), cu. ft.

6.6.2 Concentration in lb./cu. ft.

$$c_s = \frac{\left(\frac{1}{453{,}600} \ \frac{\text{lb.}}{\text{mg.}}\right) M_n}{V_{m_{std}}} = 2.205 \times 10^{-6} \ \frac{M_n}{V_{m_{std}}} \qquad \text{equation 5-5}$$

where:

C_a = Concentration of particulate matter in stack gas, lb./s.c.f., dry basis.

453,600 = Mg/lb.

M_n = Total amount of particulate matter collected, mg.

$V_{m_{std}}$ = Volume of gas sample through dry gas meter (standard conditions), cu. ft.

6.7 Isokinetic variation.

$$I = \frac{T_s \left[\frac{V_{1_c} (\rho_{H_2O}) R}{M_{H_2O}} + \frac{V_m}{T_m} \left(P_{bar} + \frac{\Delta H}{13.6}\right)\right]}{\theta V_s P_s A_n} \times 100$$

$$= \frac{\left(1.667 \ \frac{\text{min.}}{\text{sec.}}\right) \left[\left(0.00267 \ \frac{\text{in. Hg-cu. ft.}}{\text{ml.-}^\circ\text{R}}\right) V_{1_c} + \frac{V_m}{T_m} \left(P_{bar} + \frac{\Delta H}{13.6}\right)\right]}{\theta V_s P_s A_n} \qquad \text{equation 5-6}$$

where:

I = Percent of isokinetic sampling.

V_{1_c} = Total volume of liquid collected in impingers and silica gel (See Fig. 5-3), ml.

ρ_{H_2O} = Density of water, 1 g./ml.

R = Ideal gas constant, 21.83 inches Hg-cu. ft./lb. mole-°R.

M_{H_2O} = Molecular weight of water, 18 lb./lb.-mole.

V_m = Volume of gas sample through the gas meter (meter conditions), cu. ft.

T_m = Absolute average dry gas meter temperature (See Figure 5-2), °R.

P_{bar} = Barometric pressure at sampling site, inches Hg.

ΔH = Average pressure drop across the orifice (see Fig. 5-2), inches H_2O.

T_s = Absolute average stack gas temperature (see Fig. 5-2), °R.

θ = Total sampling time, min.

V_s = Stack gas velocity calculated by Method 2, Equation 2.2, ft./sec.

P_s = Absolute stack gas pressure, inches Hg.

A_n = Cross-sectional area of nozzle, sq. ft.

6.8 Acceptable results. The following range sets the limit on acceptable isokinetic sampling results:

If $90\% \leq I \leq 110\%$, the results are acceptable, otherwise, reject the results and repeat the test.

7. Reference.

Addendum to Specifications for Incinerator Testing at Federal Facilities, PHS, NCAPC, Dec. 6, 1967.

Martin, Robert M., Construction Details of Isokinetic Source Sampling Equipment, Environmental Protection Agency, APTD-0581.

Rom, Jerome J., Maintenance, Calibration, and Operation of Isokinetic Source Sampling Equipment, Environmental Protection Agency, APTD-0576.

Smith, W. S., R.T. Shigehara, and W. F. Todd, A Method of Interpreting Stack Sampling Data, Paper presented at the 63rd Annual Meeting of the Air Pollution Control Association, St. Louis, Mo., June 14-19, 1970.

Smith, W. S., et.al., Stack Gas Sampling Improved and Simplified with New Equipment, APCA paper No. 67-119, 1967.

Specifications for Incinerator Testing at Federal Facilities, PHS, NCAPC, 1967.

APPENDIX B

SUGGESTED CONTENTS OF STACK TEST REPORTS

CONTENTS OF STACK TEST REPORTS

In order to adequately assess the accuracy of any test report the basic information listed in the following suggested outline is necessary:

1. Introduction. Background information pertinent to the test is presented in this section. This information shall include, but not be limited to, the following:
   - a. Manufacturer's name and address.
   - b. Name and address of testing organization.
   - c. Names of persons present, dates and location of test.
   - d. Schematic drawings of the process being tested showing emission points, sampling sites, and stack cross section with the sampling points labeled and dimensions indicated.
2. Summary. This section shall present a summary of test findings pertinent to the evaluation of the process with respect to the applicable emission standard. The information shall include, but not be limited to, the following:
   - a. A summary of emission rates found.
   - b. Isokinetic sampling rates achieved if applicable.
   - c. The operating level of the process while the tests were conducted.
3. Procedure. This section shall describe the procedures used and the operation of the sampling train and process during the tests. The information shall include, but not be limited to, the following:
   - a. A schematic drawing of the sampling devices used with each component designated and explained in a legend.
   - b. A brief description of the method used to operate the sampling train and procedure used to recover samples.

4. Analytical Technique. This section shall contain a brief description of all analytical techniques used to determine the emissions from the source.

5. Data and Calculations. This section shall include all data collected and calculations. As a minimum, this section shall contain the following information:

    a. All field data collected on raw data sheets.

    b. A log of process and sampling train operations.

    c. Laboratory data including blanks, tare weights, and results of analysis.

    d. All emission calculations.

6. Chain of Custody. A listing of the chain of custody of the emission test samples.

7. Appendix:

    a. Calibration work sheets for sampling equipment.

    b. Calibration or process logs of process parameters.